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# Accessing Health: Examining Racial and Geographic Disparities in Diabetes Prevalence as a Result of the Built Environment

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ACCESSING HEALTH: EXAMINING RACIAL AND GEOGRAPHIC DISPARITIES IN DIABETES PREVALENCE AS A RESULT OF THE BUILT ENVIRONMENT

by

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## ABSTRACT

Diabetes is a leading cause of premature death and disability in the United States and vulnerable populations may be at increased risk. Racial residential segregation, population density, and other factors influence the built environment, which in turn affects access to health-related facilities. Using the theory of fundamental causes, this study aims to determine whether neighborhood-level sociodemographic factors, the built environment, and subsequent access to health-related facilities are associated with diabetes prevalence in Georgia's population.

A built environment assessment of all health facilities located in the state of Georgia was conducted using health data from the 2014 Behavioral Risk Factor Surveillance System and demographic data from the 2010 US Census. Geospatial techniques, including hot-spot analyses and the two-step floating catchment area method were used to determine the effect of racial concentration, socioeconomic status, and population density on access to health-related facilities and thus on diabetes prevalence. Linear and spatial regression analyses were conducted to determine the significance of the association between access to facilities and diabetes prevalence.

The results of the geospatial and regression analyses show that socioeconomic factors significantly affect the built environment, which in turn significantly influence diabetes prevalence. This interdisciplinary study contributes to the literature by providing a comprehensive analysis of the relationship between sociodemographic factors, the built environment, and diabetes prevalence in a southeastern state.

*Keywords: Diabetes, Disparities, Access, Racial Segregation, Urban/Rural, Built Environment*

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# Table of Contents

# List of Tables

# List of Figures

# 1 INTRODUCTION

The built environment influences almost every facet of Americans' lives. It contains every human-designed and human-built facility in an area. It can influence everything from family to transportation to leisure activities to consumer habits. Differences exist in the amenities that some neighborhoods offer and others do not. Neighborhoods that are more affluent tend to have greater access to healthful facilities, such as parks, recreational facilities, and supermarkets (Duncan, Castro, Gortmaker, Aldstadt, Melly, & Bennett, 2012). Thus, one of the most important factors that the built environment can influence is health.

Variations in the built environment fall under the purview of population health. Population health examines the factors that influence the health of populations, and identifies systematic variations in the patterns of occurrence of illness and disease. Recent interest in the effects of the built environment on health has arisen due to interest in social determinants of health, the use of ecologic variables in sociology, and increasing research into the intersectionality of sociology and public health in examining health issues.

Since the mid-nineteenth century, researchers have shown a link between where one lives and their health. Along with built environment factors of a neighborhood, such as locations of grocery stores, parks, liquor stores, and doctor's offices, the social environment factors of a neighborhood influence health as well. Factors such as racial makeup, median household income, educational attainment, and unemployment rates can affect which facilities are in a neighborhood, and thus the access to which residents have to improve their health. These are the basic tenets that make up the sociological theory of fundamental causes. Differential sociodemographic factors lead to differential access to facilities, which can mean differential health outcomes to vulnerable populations.

One of the most common social problems that sociologists examine is racial health disparities. Disparities exist when one group of people do not receive the same treatment, benefits, or advantages as another group for any number of social issues, which can lead to inequitable health outcomes (Institute of Medicine, 2002). Research shows that racial disparities exist for several chronic diseases, including diabetes, cardiovascular disease, hypertension, and obesity (Li, Harmer, Cardinal, Bosworth, & Johnson-Shelton, 2009; Lovasi, Hutson, Guerra, & Neckerman, 2009; Zhang & Wang, 2004). Through factors such as a differential built environment, unequal access to healthful resources such as recreation centers, supermarkets, and healthcare facilities, and through racial residential segregation, many African-Americans experience unequal health outcomes in terms of chronic disease. Higher rates of chronic disease among the African-American population can lead to increased medical costs, work loss, a decreased quality of life, or even premature death. African-Americans have higher mortality rates than any other group in the United States, and the mortality rate for chronic diseases such as heart disease and diabetes for African-Americans continues to rise (Frist, 2005; Hummer, Rogers, Nam, & LeClere, 1999; Schulz, Williams, Israel, & Lempert, 2002).

Diabetes is the seventh leading cause of death in the United States (Centers for Disease Control and Prevention (CDC), 2014a). It is a serious illness with a large societal burden, in both cost and years of potential life lost. Risk factors associated with diabetes include high blood pressure, high cholesterol, tobacco use, cardiovascular disease, obesity, lack of physical activity, gender, and age (Link et al., 2009). Racial disparities exist in diabetes prevalence. African-

Americans are 50%-100% more likely to have diabetes than Caucasians (Signorello, Schlundt, Cohen, Steinwandel, Buchowski, McLaughlin, & Blot, 2007). There are several hypotheses as to why racial disparities in diabetes prevalence exist for African-Americans, which will be discussed in greater detail below. These disparities can negatively affect health at an earlier age for this population than for others.

## 1.1 Research Problem

Racial and socioeconomic disparities exist in diabetes prevalence. Additionally, disparities exist in the built environment, including access to healthful facilities. There are two overarching questions this study will attempt to answer. First, how does neighborhood composition affect the built environment? Second, how does neighborhood composition and built environment together affect diabetes prevalence? The purpose of this study is four-fold. The first is to determine the extent to which sociodemographic factors and neighborhood composition affect the built environment. Related to the first, I will examine whether racial segregation and neighborhood disadvantage influence which facilities are accessible to residents. Third, I will determine whether differential access to facilities (both healthful and harmful) affect a county's diabetes prevalence. Finally, I will look at geographic differences in diabetes prevalence throughout the state of Georgia to determine whether urban or rural residence negatively affects diabetes prevalence.

## 1.2 Contribution

This dissertation will contribute to fundamental causes theory and the overall field of sociology by helping to explain differences in access to healthful facilities and the health conditions that can result as a consequence. Fundamental causes theory examines the causes of health and disease as a spectrum ranging from individual factors to broad social issues (Link & Phelan, 1995). The main theoretical claim is that social conditions are fundamental causes of health, rather than confounders or clues to more proximal factors (Link & Phelan, 2005). Another major assumption of fundamental causes theory is that social conditions change over time. As equal access to a health benefit occurs, other conditions will replace those and health disparities will continue. For example, health disparities used to be common for many infectious diseases early in the 1900s. As health conditions and health education improved for all populations in the United States, health disparities in infectious disease declined. As infectious disease prevalence declined overall, chronic disease prevalence increased, and health disparities became more prevalent for chronic disease than infectious disease. Under the theory of fundamental causes, health disparities will never disappear. They will merely be replaced by other sociodemographic or economic factors, unless we directly address the fundamental cause.

Examples of fundamental causes of disease include socioeconomic status (SES) and resources, such as money, knowledge, power, prestige, strong social support, and networks (Link et al., 1995). This study contributes to the literature by applying fundamental causes theory to the physical (or built) environment as well as to the social environment. Further, the examination between the built environment and diabetes has not been thoroughly examined. This study will fill a gap in the built environment and diabetes research. Finally, this research will provide policy suggestions for urban planning and public health.

In the next chapter, I go into detail about the fundamental causes framework, from its history to common applications of fundamental causes theory. Chapter three discusses diabetes, including types of diabetes, risk factors, and racial and geographic disparities in diabetes prevalence. Chapter four presents and discusses the sociological background for this study. This includes an exhaustive literature review on the built environment, the built environment's effect on health, as well as residential segregation and its effect on health. Chapter five delves into the methodology and the plan of analysis for this research. First, I describe the sample in detail, including all constructs and measures, and then I discuss the plan of analysis. This includes both a geospatial analysis and a regression analysis to determine the extent to which access to facilities contributes to racial disparities in diabetes prevalence. Chapter six examines the analyses and attempts to answer how does neighborhood composition influence the built environment? Chapter seven is a second results chapter, and examines the second question of how does neighborhood composition and built environment together affect diabetes prevalence. Chapter eight discusses the results from chapters six and seven, along with hypothesis testing, and a discussion of limitations and future research. Finally, chapter nine concludes this dissertation. With this information, I expect to determine whether there are statistically significant differences in access to facilities, and whether differential access due to differences in sociodemographic factors contributes to racial disparities in diabetes prevalence.

# 2 THEORETICAL FRAMEWORK: FUNDAMENTAL CAUSES THEORY

Over the last century, there has been dramatic improvement in population health (Phelan & Link, 2005). Infectious diseases that used to affect the population in the United States, such as pneumonia, tuberculosis, and diphtheria have declined to near non-existence. Life expectancy has also increased dramatically. In 1900, the life expectancy was only about 47 years, whereas now it has nearly doubled to 82 years. However, life expectancy and health have not increased equally (House, Kessler, & Herzog, 1990).

Ever since the mid-1800s, researchers have shown a link between SES and health (Link, Northridge, Phelan, & Ganz, 1998; Phelan et al., 2005). In the last one hundred years, there has been a shift in both the types of diseases that affect the population and the health care management systems that exist (Link et al., 1998). Specifically, infectious disease prevalence has declined rapidly, while being replaced by chronic disease prevalence (Phelan et al., 2005). Medical advancements have also helped improve the health of the population, including screenings, promotion of exercise and good nutrition, and smoking cessation (Phelan et al., 2005).

For all the improvements in population health in the last century, research in multiple fields continues to focus on individual factors and behaviors that contribute to individual health. Research in fields such as medicine, epidemiology, behavioral medicine, and social epidemiology have, in the past, tended to focus on behavioral or other proximate risk factors for disease (Phelan, Link, Diez-Roux, Kawachi, & Levin, 2004). Another field, risk factor epidemiology, has downplayed social conditions as causes of poor health. Researchers in this field tend to see social issues as clues to individual illnesses instead (Link et al., 2005).

Instead of examining poor health and disease through a lens of either individual factors or social issues, it may be more useful to think of the causes of health and illness as a spectrum ranging from individual factors to broad social issues (Link & Phelan, 1995). As stated above, much of the research in the last century has focused on individual factors, while downplaying the role of SES or other social issues (Phelan et al., 2004). Social factors are more distal (Link et al., 1995). In the past, SES, as an example, was often used as a confounding variable instead of a causal variable (Adler, Boyce, Chesney, Cohen, Folkman, Kahn, & Syme, 1994; Phelan et al., 2004). Further, social factors were seen to be specious or unimportant (Link, 2008). Dominant research strategies assumed that distant social factors could be explained by the more proximal individual-level causes of disease (Phelan et al., 2004). Research that focused on more proximate risk factors was popular among scientists for a couple of reasons. First, the idea that individuals are in charge of their own health, and poor health was the result of poor choices made by an individual, resonates well with the idea of meritocracy and the Puritan ethic, ideas that are still considered relevant today (Link et al., 1995). Second, it is true that disease does not leap directly from social factors such as income, education, or occupational status into the body (Phelan et al., 2004). No fixed set of social risk or protective factors can be connected directly to life-threatening diseases (Link, Phelan, Miech, & Westin, 2008). However, poor health also cannot be explained solely by individual factors either. There are drawbacks to emphasizing individual factors. First, a focus on individual factors can neglect the importance of social conditions on health. Second, research on single mechanisms can neglect the multivariate processes through which social factors can affect health (Link et al., 1995).

While researchers in the last century have emphasized individual factors pertaining to health and illness, in the last few years there has been increased attention paid to macro-level influences on health, such as income inequality, social cohesion, and racial segregation and discrimination (Link et al., 2005). There has also been increased attention to multiple levels of social and economic factors, such as the effect of one's neighborhood or community on individual health (Link et al., 2005). As some researchers argue, looking at the institutional factors that put people at risk is just as important as the individual or biological factors closer to disease (Link et al., 1995; Link et al., 1998). In doing so, it helps to explain the persistence of the association between SES and health even while disease risks change. When new risk factors for chronic disease replaced infectious disease, the socioeconomic differences for chronic disease just became more apparent (Link et al., 1996). To this day, serious socioeconomic and racial disparities exist in the prevalence of chronic disease that were essentially non-existent in the early 1900s (Frohlich, Ross, & Richmond, 2006; Link et al., 1996; Williams et al., 2009; Willson, 2009).

So, if social factors have become more important in the last few years to help explain differences in health and the changes in chronic and infectious disease risk, then which intervening factors affect health? In the past, diphtheria, measles, and typhoid fever were essentially eradicated with increased attention to sanitation and immunization (Link et al., 1995). Original risk factors were simply replaced with others. As chronic disease becomes more prevalent in our society, smoking, exercise, and diet have become more prominent risk factors that affect health. In other words, medical advances in general have changed the risk factors that most affect health today. Access to care for the poor has also helped improve the health of the population (Link et al., 1995). Yet, there is an enduring, in some cases increasing, association between SES and disease. When important mediating risk factors have been reduced or eliminated altogether, socioeconomic gradients in mortality have remained undiminished (Phelan et al., 2004). What is happening, per Link et al. (1995), is that a deeper sociological process is at work.

The theory of fundamental causes was developed to address the sociological processes behind the steady association between SES and disease. The theory of fundamental causes grew from the separate works of three researchers, Thomas McKeown, Stanley Lieberson, and Pierre Bourdieu. McKeown developed his ideas in the mid-1980s. His main argument states that "the enormous improvements in health experienced over the past two centuries owe more to changes in broad economic and social conditions than to specific medical advances," and that reductions in mortality were also due to improved socioeconomic conditions (Link & Phelan, 2002, Link et al., 2005, p. 71). Lieberson (1985) receives credit for producing the roots of fundamental causes in his theory of basic causes, which states that risk factors have an enduring effect on health, but also that as the effect of one risk factor declines, another emerges to take its place (Link et al., 2005). Finally, Pierre Bourdieu provided the background for the socioeconomic characteristics of fundamental causes theory. In his work, he proposed that social class groups profit in a differential manner from unequal access to economic capital (such as money, time, and wealth), cultural capital (such as knowledge, education, family background, and history), and social capital (such as social networks, connections, and institutional links) (Pierre, 1980).

Fundamental causes was further developed as a theory by Bruce Link and Jo Phelan in the early 1990s. Their main theoretical claim is that social conditions are fundamental causes of health, rather than confounders to more proximal factors (Link et al., 2005). Social conditions are defined as “factors that involve a person’s relationships to other people” (Link et al., 1995, pg. 81). Further, social inequalities produce health inequalities, and they suggest that policies that benefit all rather than just a few would be much more effective in reducing health disparities (Link et al., 2005). According to the researchers, fundamental causes theory states that health disparities are persistently associated with social or physical factors despite dramatic changes in diseases, risk factors, and health interventions (Hatzenbuehler, Phelan, & Link, 2013). Additionally, Link and Phelan state the following:

> “A fundamental social cause involves resources like knowledge, money, power, prestige, and social connections that strongly influence people’s ability to avoid risks and to minimize the consequences of disease once it occurs (Link et al., 1996, p. 472) . . . The reason for such persistent associations, and the essential feature of fundamental social causes, is that they involve *access to resources* that can be used to avoid risks or to minimize the consequences of disease once it occurs” (Link et al. 1995, p. 87, emphasis mine).

Fundamental causes is a dynamic, fluid framework that is dependent on change over time (Link et al., 1995). In fact, fundamental causes only become apparent under conditions of change. These could be changes in disease, treatment, risks, or knowledge of risks (Link et al., 1996). If our medical and social systems were static, then as each risk factor was eliminated, the association between social conditions and disease would also decline, but research shows that this is not the case (Link et al., 1996).

Overall, fundamental causes theory states that one’s SES has an influential effect on one’s health, through one’s access to resources, ability to afford said resources, and the support to maintain good health (Phelan et al., 2004). Two of the main facets of their theory, SES and resources, require further definition. SES is defined a number of ways by a number of researchers. However, the most common definition of SES is developed through a composite of variables such as median household income, family poverty rate, education, and occupation. These factors are accepted by Link and Phelan and have been corroborated through a principal components analysis by Singh et al. (2002). Dutton & Levine (1989) provide a similar definition for SES: "[It is] a composite measure that typically incorporates economic status, measured by income; social status, measured by education; and work status, measured by occupation" (p. 30).

According to Link and Phelan, resources include money, knowledge, power, prestige, strong social support, and networks (Link et al., 1995; Link et al., 1998; Phelan et al., 2004; Phelan et al., 2005). We use these resources to distribute and collect knowledge about health, disease, and mortality (Phelan et al., 2005). Sociologically, it is up to humans to decide how and where information is distributed (Link, 2008). As Susser et al. (1985) states, societies create the disease they experience and shape the way diseases are experienced. In effect, the health of the US population can be attributed, to some extent, to the influence of social factors and the disparities evident in knowledge dissemination (Link, 2008). Resources are flexible, in that they can either directly shape individual health behaviors by influencing what people are aware of, have access to, or can afford, or they can shape access to broad contexts such as neighborhoods that can vary overall in their risk or protective factors (Link et al., 2008; Phelan et al., 2005). Additionally, resources can be deployed at the individual level (to construct a healthy lifestyle), or at the community level (to gain access to safe neighborhoods or good jobs) (Link et al., 2008). As Phelan, Link, & Tehranifar (2010) state, "once a person has used SES-related resources to locate in an advantaged neighborhood, a host of health-enhancing circumstances comes along as a package deal” (p. S30).

One of the main tenets of Link and Phelan’s theory of fundamental causes is that social factors are fundamental causes of disease. This has been demonstrated repeatedly in the literature, perhaps most notably with Marmot et al.’s (1984) Whitehall study of mortality. This study was striking in that it controlled for variables that had previously not been controlled, and the sample was homogeneous. All of the workers worked for the civil service, and all had access to nationalized health care. Yet, the results showed a health hierarchy extremely well-associated with a worker’s income. The health of the higher income workers was better than the health of lower income workers in a linear fashion. Overall, this and other studies have shown that SES and mortality are closely related (Adler et al., 1994, Marmot et al., 1984).

There is a strong, well-established, and robust association linking morbidity and mortality to SES indicators such as educational attainment, occupational standing, and income (Phelan et al., 2005). As stated above, people higher in the hierarchy tend to enjoy better health than those below (Adler et al., 1994). What is interesting is that the association between SES and health occurs at all levels of the hierarchy, but the magnitude of the effect of SES and health is much larger at lower income and education levels (Adler et al., 1994; Marchand, Wikler, & Landesman, 1998; Mechanic, 2002). For example, a recent study showed that people at the bottom of the income and education hierarchies are two to three times more likely to die within 10 years than those in a higher level (Link et al., 1998). Additionally, people with a higher SES were more likely to have access to greater resources to take advantage of health-enhancing opportunities (Mechanic, 2002).

Socioeconomic differences are found for both morbidity and mortality in almost every disease that affects humanity (Adler et al., 1994; Frohlich et al., 2006). Low SES is related to mortality for each of the fourteen major causes of death in the International Classifications of Diseases (Phelan et al., 2010). Overall, the richer live longer and the poorer die earlier. In addition, the poor are sicker while they're alive and are five times more likely to report being in fair or poor health than the rich (Frohlich et al., 2006; Marchand et al., 1998). As Williams & Jackson (2005) state, "Americans with low SES have levels of illness in their thirties and forties that are not seen in groups with higher SES until three decades of age later" (p. 327). Further, there is evidence that SES is associated with certain risk and protective factors. For example, studies have shown that people in lower SES strata have higher measures of smoking, overweight and obesity, sedentariness, stress, social isolation, a lack of preventive health care, and malnutrition (House et al., 1990; Phelan et al., 2010).

While fundamental causes theory focuses primarily on socioeconomic inequality and not on racial inequality, there are large and persistent socioeconomic and racial-ethnic disparities for many diseases (House, 2002). In fact, Link and Phelan have been criticized for their inadequate attention to the causes of racial disparities in both SES and health, which they addressed in their 2015 work (Phelan & Link, 2015; Williams & Collins, 2001). Link and Phelan determined that there are two fundamental associations between race/ethnicity and health. First, that there is fundamental association between systemic racism and racial inequalities in SES and second, that there is an association between SES and inequalities in health outcomes. Considering race and ethnicity within fundamental causes theory is important. Socioeconomic status is one of the strongest known determinants of variations in health status, and race in the United States is strongly intertwined with SES (Williams & Sternthal, 2010). African-Americans are more likely to report being in fair or poor health than Caucasians, and have higher rates of overall mortality, infant mortality, tuberculosis, and several other myriad diseases (Williams et al., 2001). Further, research has indicated that more than 100,000 African-Americans die prematurely than would if there were no racial disparities in health at all (Levine, Foster, Fullilove, Fullilove, Briggs, Hull, … & Hennekins, 2001). For SES, the measures of socioeconomic status are not equivalent across race. Studies that have controlled for socioeconomic indicators, such as education, have shown that African-Americans are still more likely to be unemployed, have more hazardous work conditions, lower wealth at all levels of income, and less purchasing power in segregated areas (Williams & Mohammed, 2009). Therefore, including race within fundamental causes theory is imperative.

There are other factors to consider regarding fundamental causes theory that should be addressed. One is the issue of causal direction and competing theories of causal explanation. Does low socioeconomic status cause poor health or does poor health cause downward mobility? Link et al. (1995) has addressed this question through approaches such as quasi-experimental strategies and longitudinal designs. Overall, while the researchers cannot completely rule out the idea that illness can affect social conditions, there is substantial evidence that social conditions can cause or exacerbate illness (Link et al., 1995). Additionally, there is general agreement that SES is associated with health, and not the other way around (House et al. 1990).

Another causal explanation for the relationship between SES and health is stress theory, popularized by Adler et al. (1994) and others. This is a popular theory that states that those at the bottom of a hierarchy are more stressed, which creates vulnerability to disease (Adler et al., 1994; Link et al., 1995; Link et al., 1998; Phelan et al., 2005). This can be stress associated with lower SES and/or stress related to a minority racial status (including discrimination and racism) (Phelan et al., 2005). However, Link et al. (1998) argues that this theory expects a relatively consistent association between SES and stress-related diseases. There are discrepancies to this assumption. For example, a half a century ago, SES and heart disease used to have a positive correlation, but in current times the association between the two is inverse (Link et al., 1998).

A third causal theory considers the differences in high risk behaviors. This is another prominent hypothesis that states that social inequalities in mortality in those of a lower SES are due to the higher prevalence of health risk health behaviors (Lantz, House, Lepkowski, Williams, Mero, & Chen, 1998). However, research has shown that SES differences in mortality are due to a wide array of factors, and not just high risk health behaviors. In fact, the influence of major health risk behaviors on mortality only explains a relatively small proportion of the relationship (Lantz et al., 1998). Overall, while there are several theories that compete with fundamental causes to explain the relationship between socioeconomic status and health, research shows that no one theory can explain the relationship fully. For the purposes of this study, fundamental causes theory provides an appropriate framework to address access to resources and the prevalence of diabetes in the population of Georgia.

As fundamental causes theory becomes more prominent in the literature, there have been several calls to action to further develop its framework and to apply fundamental causes theory to different situations and ideas. As McKinlay (1996) states, a more focused, guided social epidemiology would help promote a more focused view of illness and enhance our understanding of threats to human health. Link and Phelan (1995) themselves call for an examination of the broader determinants of the resources that fundamental causes entail.  Link (2008) agrees, stating that there is a need for epidemiological sociologists whose focus is on factors outside those labeled as fundamental causes by Link and Phelan to examine the association between social factors and health.

In this research, I plan to answer other researchers' calls to action by applying fundamental causes theory to the physical and built environment. Link and Phelan (2005) state that fundamental causes operate through multiple risk factors, including but not limited to those mentioned above (such as money, knowledge, power, prestige, and social connections) (Hatzenbuehler et al., 2013). As stated earlier, the "essential feature of fundamental social causes is that they involve *access to resources* that can be used to avoid risks or to minimize the consequences of disease once it occurs" (Link & Phelan, 1995, p. 87, emphasis mine). I argue that the physical environment may also be considered an outcome of the sociodemographic factors of fundamental causes, and that physical access to resources may also affect health. I will apply fundamental causes theory to my research to show that physical access to several resources in the built environment can affect diabetes prevalence in the population throughout Georgia.

# 3 DIABETES

Diabetes is a chronic, common disease in the United States. In fact, as of 2010, the United States had the highest prevalence of diabetes among seventeen peer countries (Woolf & Aron, 2013). It is defined as "a group of diseases marked by high levels of blood glucose resulting from problems in how insulin is produced, how insulin works, or both" (CDC, 2014a, p. 9). There are several types of diabetes. The first is type 1 diabetes, also known as insulin-dependent diabetes mellitus or juvenile-onset diabetes. Approximately 5% of all diagnosed cases of diabetes for adults is type 1 (CDC, 2014a). There is no known way to prevent type 1 diabetes, and it is much more common among Caucasians than any other race (CDC, 2014a; Karter, Ferrara, Liu, Moffet, Ackerson, & Selby, 2002).

The second is type 2 diabetes. This is also known as non-insulin dependent diabetes or adult-onset diabetes. This type accounts for up to 95% of all adult diagnoses of diabetes. The focus of this study involves people with type 2 diabetes, and is referred to hereafter as either type 2 diabetes or simply diabetes. Type 2 diabetes is one of the most common non-communicable diseases in the world today (Green, Hoppa, Young, & Blanchard, 2003). Over 29.1 million people in the United States have diabetes (CDC, 2014a). This is 9.3% of the country's population. Of this 29.1 million, 21 million people have been diagnosed. This means that almost 8 million people in the United States have diabetes, but have not been formally diagnosed. In 2012, 37% of US adults have prediabetes (CDC, 2014a). This is an additional estimated 86 million Americans. In the last couple of decades, there has been a rise in the prevalence of diabetes (Booth, Hux, Fang, & Chan, 2005). In 1990, the percentage of Americans with diabetes was 2.52%, or 6.21 million people. By 2012, this number had risen to 6.96%, or 21.47 million people (CDC, 2014b). There are other types of diabetes, such as gestational, maturity-onset diabetes of youth, and latent autoimmune diabetes, but these make up a small proportion of total diabetics.

Diabetes is a serious illness with a large societal burden, both in cost and in years of potential life lost (LaViest et al., 2009; Srinivasan et al., 2003). The Centers for Disease Control and Prevention estimate that direct medical costs associated with diabetes are $176 billion annually. These are average medical expenditures (CDC, 2014a). Indirect costs, such as those associated with disability, work loss, and premature death, average $69 billion annually. In the last two decades, however, the quality of care associated with diabetes has improved (McWilliams, Meara, Zaslavsky, & Ayanian, 2009). Researchers have shown that blood pressure control, glucose level control, and cholesterol levels have also improved for adults with diabetes. This improved treatment has had an impact on mortality rates, decreasing by 5% in the last couple of decades (McBean, Li, Gilbertson, & Collins, 2004; McWilliams et al., 2009).

There are several risk factors associated with diabetes. The first is high blood pressure (CDC, 2014a; Link & McKinlay, 2009). In 2009-2012, of those who had diagnosed diabetes, 71% also had high blood pressure and/or were taking medications to lower blood pressure. The second is high lipids, or high cholesterol. In 2009-2012, of those who had diagnosed diabetes, 65% had high bad cholesterol and/or were taking medications to lower cholesterol (CDC, 2014a). Other risk factors include tobacco use, cardiovascular disease, obesity, physical activity, gender, and age (Link et al., 2009). Along with these biological and demographic factors, diabetes is also strongly affected by behavioral, cultural, and environmental factors that cluster on and overlay genetic susceptibility (Barker, Kirtland, Gregg, Geiss, & Thompson, 2011). These will be described in greater detail below.

There are multiple complications that are associated with diabetes. The first is heart disease and stroke. Cardiovascular disease deaths were about 1.7 times higher among adults with diabetes than those without diabetes. Further, hospitalizations for stroke were 1.5 times higher among adults with diabetes (CDC, 2014a). The second is blindness. Of adults diagnosed with diabetes, 2.8% had diabetic retinopathy, which is damage to the small blood vessels in the retina (CDC, 2014a). Third is kidney failure. Diabetes was listed as the primary cause of kidney failure in 44% of all new cases in 2011 (CDC, 2014a; Karter et al., 2002). Fourth is lower-limb amputation. About 60% of non-traumatic lower-limb amputations among people aged 20 and older occur in people with diagnosed diabetes (CDC, 2014a; Karter et al., 2002). Other less common conditions include nerve disease, non-alcoholic fatty liver disease, periodontal disease, hearing loss, erectile dysfunction, depression, and complications with pregnancy (CDC, 2014a). These complications can lead to death. In 2010, diabetes was the seventh leading cause of death in the United States. The rates of death from all causes were about 1.5 times higher among adults with diagnosed diabetes than among adults without (CDC, 2014a).

Treating diabetes is possible. People with diabetes need to be able to self-manage their illness to prevent complications (Duru, Gerzoff, Selby, Brown, Ackermann, Karter, & Mangione, 2009). Behavioral and mental health issues such as depression, low health literacy, incomplete medication adherence, low self-efficacy, and poor patient-provider communication have been associated with adverse health consequences (Bosworth, Dudley, & Olsen, 2006; DiMatteo, Giordani, Lepper, Croghan, 2002; DiMatteo, 2004; Duru et al., 2009; Fisher & Glasgow, 2007;

Galvan & Caetano, 2003; Gary, Crum, Cooper-Patrick, Ford, & Brancati, 2000; Heisler, Faul, Hayward, Langa, Blaum, & Weir, 2007; Saha, Arbelaez, & Cooper, 2003; Sentell & Halpin, 2006; Smedley & Syme, 2001). Diabetes can be treated predominately by healthy eating and regular physical activity. Further, medications can be taken to lower blood glucose levels, which reduce the risk of developing the diabetic complications above (CDC, 2014a).

### 3.1 Racial Disparities in Diabetes

Healthy People is a national health promotion initiative designed to improve the health of all Americans. Healthy People 2010 was the first to call for the elimination of racial disparities in health and health care by 2010 (McBean et al., 2004). In Healthy People 2020, the goal was further expanded to achieve health equity, eliminate disparities, and improve the health of all groups (Office of Disease Prevention and Health Promotion (ODPHP), 2015). Healthy People 2020 defines a health disparity as

> "A particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage. Health disparities adversely affect groups of people who have systematically experienced greater obstacles to health based on their racial or ethnic group; religion; socioeconomic status; gender; age; mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; or other characteristics historically linked to discrimination or exclusion" (ODPHP, 2015).

The Healthy People 2020 goal for diabetes is to reduce the disease and economic burden of diabetes mellitus and improve the quality of life for all persons who have been diagnosed with, or are at risk for, diabetes (ODPHP, 2015). Racial disparities in diabetes has become a prominent issue in decades about health care and civil rights, and reducing these disparities is a high priority of US public health policy (Plescia, Herrick, & Chavis, 2008; Zhang, Wang, & Huang, 2009).

African-Americans suffer disproportionately from many chronic diseases, including diabetes. Overall, African-Americans have higher mortality rates than any other group for chronic diseases (Frist, 2005; Hummer, Rogers, Nam, & LeClere, 1999). In fact, African-Americans are 50% to 100% more likely to have diabetes than Caucasians (Signorello, Schlundt, Cohen, Steinwandel, Buchowski, McLaughlin, & Blot, 2007; Shulz et al., 2002; Zenk et al., 2005a). Of all racial populations, Caucasians tend to have the lowest levels of diabetes, while American Indians have the highest levels, followed closely by African-Americans (CDC, 2014a; LaViest et al., 2009). Other research has shown that minority group status remains an independent risk factor for diabetes, even after controlling for body mass index (BMI) and socioeconomic status (SES). While blood pressure control, glucose control, and cholesterol levels have improved in the last couple of decades for persons with diabetes, the racial and socioeconomic differences have not narrowed significantly (McWilliams et al., 2009). There are also trends in racial disparities in the prevalence of diabetes varied by BMI. One research study showed that those in a normal weight group saw increasing racial disparities. In the overweight group, racial disparities worsened as diabetes prevalence increased 33.3% in Caucasians and 60% in blacks. However, minimal disparities were observed in obese and severely obese groups over time, indicating that racial and ethnic disparities in diabetes prevalence have become more pronounced in normal and overweight groups (Zhang et al., 2009). This has been corroborated in other research as well (Lovasi et al., 2009). This is significant, in that over time, African-Americans are at an increasing health disadvantage relative to Caucasians (Shuey & Willson, 2008).

Why do racial disparities in diabetes prevalence exist? There are several hypotheses that attempt to explain why racial disparities in diabetes prevalence persist in the United States. Some studies have suggested that disparities in diabetes prevalence can be attributed to differences in healthcare resource allocation, healthcare utilization, quality of diabetes care, dietary habits, physical activity, perceived self-efficacy, and genetics (Bachmann, Eachus, & Hopper, 2003; Figaro, Elasy, BeLue, Speroff, & Dittus, 2009; LaViest et al., 2009; Maskarinec, Grandinetti, Matsuura, Sharma, Mau, Henderson, & Kolonel, 2009; Miller, Schlundt, Larson, Reid, Pichert, Hargreaves, Brown, McClellan, & Marrs, 2010; Sesquist, Fitzmaurice, Marshall, Shaykevich, Safran, & Ayanian, 2008). Other studies have suggested that behavioral, environmental, socioeconomic, and physiological factors contribute to these disparities as well (Signorello et al., 2007). Yet other studies have suggested that a lower socioeconomic status is a predominant factor in differences in diabetes prevalence (Karter et al., 2002; Link et al., 2009). For example, Link et al. (2009) found in their research that people in lower socioeconomic strata were up to three times more likely to be diagnosed with diabetes compared to people that are more affluent. Finally, some studies propose that disproportionate enrollment in health plans with poorer performance are to blame. They suggest that racial and ethnic minorities and those of a lower socioeconomic status are much more likely to be uninsured, and associated reductions in access to quality health care contributes to these disparities (Karter et al., 2002; McWilliams et al., 2009). Yet, many researchers have shown that racial disparities in diabetes prevalence continue to exist even after controlling for health insurance status and modifiable behavioral variables such as smoking, alcohol use, BMI, glucose monitoring, exercise, and diet. This area of research is hampered by two challenges. First, the confounding of race and socioeconomic status in the United States makes it difficult, if not impossible, to separate the two variables. Thus, it is extremely difficult to say for certain whether disparities in diabetes prevalence can be primarily attributed to solely race or socioeconomic status. The second challenge is the issue of racial residential segregation. Geographic groupings of people by race can lead to different environmental and social risk exposures, which can increase diabetes disparities (LaViest et al., 2009). As Signorello et al. (2007) states, “because socioeconomic (and associated environmental) differences between racial groups are so pervasive, attempts to isolate an effect of race will typically involve substantial confounding” (p. 2260). This will be discussed in greater detail below.

### 3.2 Race, Socioeconomic Status, and Diabetes Disparities

Controlling for socioeconomic status in determining racial disparities in diabetes prevalence is difficult, because SES generally stands as a proxy for several other confounders, is difficult to quantify, and is prone to measurement error (Signorello et al., 2007). However, many researchers have attempted to do just that. Many social epidemiologists continue to find that socioeconomic status may be a more important determinant of diabetes prevalence than race alone (Link et al., 2009). In comparison with Caucasian-Americans, African-Americans tend to be poorer, have less educational attainment, are more likely to live in distressed households, and are less able to access quality health care (Link et al., 2009; Signorello et al., 2007). Diabetes prevalence tends to be inversely associated with income (Frohlich, Ross, & Richmond, 2006). These major differences in diabetes prevalence may simply reflect differences between African-Americans and Caucasians and their respective socioeconomic statuses.

Within every level of SES, African-Americans have worse health than Caucasians (Shuey et al., 2008). Socioeconomic status is considered a marker for some risk factors for diabetes, such as BMI, physical activity, hypertension, and gestational diabetes (Link et al., 2009). Overall, African-Americans have greater odds of having diabetes compared to Caucasians. However, when studies attempt to control for socioeconomic status by examining diabetes prevalence in areas that are more integrated and have a similar median household income, they find that diabetes outcomes are much more similar. Further, race disparities in diabetes may stem from differences in the health risk environments (i.e. where one resides) that African-Americans and Caucasians live (LaViest et al., 2009). Other studies have found similar results. Both Link et al. (2009) and Signorello et al. (2007) found that there was little evidence of a higher prevalence of diabetes between African-Americans and Caucasians once socioeconomic status is controlled.

### 3.3 Disparities in Diabetes Control

Many studies show that compared to Caucasians, African-Americans with diabetes have poorer control over their hemoglobin A1C, higher blood pressure, higher cholesterol, and higher rates of morbidity and microvascular complications (Duru et al., 2009; Karter et al., 2002; Sequist et al., 2008; Shuey et al., 2008; Signorello et al., 2007). Conversely, research shows that Caucasian patients are more likely than African-American patients to achieve control over their hemoglobin A and blood pressure (Sequist et al., 2008). Because of this, African-American patients are more likely to experience poor long-term diabetic outcomes, including diabetic retinopathy, lower extremity amputations, chronic kidney disease, and other factors that were mentioned above (Sequist et al., 2008). A couple of explanations given for poorer control over diabetes for African-Americans include stress and depression (Duru et al., 2009; Signorello et al., 2007). The stronger link between depression and poor control for African-Americans may be related to different social experiences between African-Americans and Caucasians, including racial discrimination, increased exposure to social stressors, and limited coping and social support (Duru et al., 2009; Shuey et al., 2008; Signorello et al., 2007). Other explanations are likely as well, as sociodemographic factors only explained up to 38% of the racial differences in diabetes control (Sequist et al., 2008). The important thing to note is that disparities based on race do exist for diabetes control, especially over hemoglobin A1C, blood pressure, cholesterol, and microvascular issues.

### 3.4 Disparities in Healthcare

Along with socioeconomic disparities and disparities in diabetes control, there are also racially-based disparities in healthcare delivery and quality. Multiple studies identify racial disparities in the delivery of diabetes care (Baicker, Chandra, & Skinner, 2005; Duru et al., 2009; Harris, 2001; IOM, 2002; Schneider, Zaslavsky, & Epstein, 2002; Sequist et al., 2008). Essentially, their results state that racial and ethnic minorities receive lower quality healthcare than Caucasians, even when they are insured to the same degree and when other healthcare access-related factors, such as the ability to pay, are the same (IOM, 2002). Baicker et al. (2005) finds that the quality of care received by African-Americans deteriorates as the African-American population in an area increases. Interestingly, the same pattern holds true for Caucasians as well. The quality of diabetes care that Caucasians receive is related to the proportion of African-Americans in a community (Baicker et al., 2005). Sequist et al. (2008) found that racial differences in diabetes care is associated with patient characteristics and within-physician effects. African-American patients with diabetes are less likely than Caucasian patients to receive the recommended processes of care, while also experiencing less ideal outcomes than Caucasian patients who have the same physicians (Sequist et al., 2008). However, other researchers have found that racial disparities in diabetes outcomes are reduced in managed-care settings (Brown, Gregg, Stevens, Karter, Weinberger, Saford, & Beckles, 2005). LaViest et al.

(2009) agrees, stating that when African-Americans and Caucasians access similar healthcare facilities, their health outcomes are more similar.

In 2002, the Institute of Medicine (IOM) examined over one hundred studies that assessed the quality of healthcare for different minority groups, while holding constant the variables of income, insurance status, and other access-related factors (IOM, 2002). What they found is that the clear majority of studies indicated that minorities were less likely than Caucasians to receive necessary services. While the IOM's meta-analysis was not specifically focused on diabetes, it found that racial disparities exist in several disease areas, including cancer, cardiovascular disease, HIV/AIDS, diabetes, and mental illness. Further, disparities were found across a range of procedures as well. The IOM and other researchers agree that racial disparities in diabetes care exists. They also agree that sociodemographic variables can contribute to racial disparities. Finally, most researchers agree that prejudice and discrimination in the healthcare system contribute to racial disparities as well. Finally, disparate access to quality health care is a common explanation for disparities in diabetes complications (Karter et al., 2002; Shuey et al., 2008).

### 3.5 Geographic Disparities in Diabetes

In the last few years, researchers have begun to focus on the idea that where one lives can drastically affect one's health. In the United States, there is significant racial residential segregation by race. In the Southeast, this clustering is more dramatic, as African-Americans are disproportionately represented in this area (Baicker et al., 2005). Where a person lives can have a large impact on the quality or level of health care accessible to them. Certain subgroups, especially African-Americans, experience higher rates of illness and complications from illness that are potentially preventable compared to the overall population (Booth et al., 2005). One of the reasons behind this is that minority populations tend to live in different areas than Caucasians (Baicker et al., 2005). Sampson and Wilson (1995) corroborate this, stating that “in not one city over 100,000 in the United States do blacks live in ecological equality with whites” (p. 42). On the other hand, some researchers argue that geography could work in favor of African-Americans, since minorities tend to be closer to the inner city, and theoretically have greater access to health-improving facilities (Baicker et al., 2005). However, the same researchers find that while most African-Americans do live in urban areas, they also tend to live in areas that have a disproportionate share of low-quality providers. Both Caucasians and African-Americans receive low-quality care in these areas, but African-Americans are overrepresented.

Recent research has also shown that while geographic racial disparities exist in disease prevalence, there is variation in racial disparities across geographic lines, as well as variation in disparities in illness. Another issue to take into consideration when determining racial disparities in disease is geographic density. Variation in health outcomes for many diseases, including diabetes, has been observed across geographic regions, and favors urban areas over rural areas (Booth et al., 2005). Many studies tend to either use a national sample to study racial disparities in healthcare access, or they extrapolate from single areas or hospitals to a wider area (Baicker et al., 2004). This generalizability hides the fact that some geographic areas have higher disparities in one disease or medical procedure, but not another (Baicker et al., 2004). An example of this is diabetes. Racial and geographical disparities in diabetes are more prevalent in some areas of the United States than others.

Mapping and statistical analyses have revealed substantial clustering and small-area variations in the prevalence of diabetes (Green et al., 2003). In fact, some researchers have identified a 'diabetes belt', which ranges across most of the Southeast (Barker et al., 2011). People living in the diabetes belt are more likely to be African-American, sedentary, and obese. The prevalence of diabetes in this belt is 11.7%, compared to the country at 8.5%. The researchers determined that 30% of the excess risk for those in the diabetes belt was associated with modifiable factors, such as diet and exercise, while 37% of the excess risk was associated with generally non-modifiable factors, such as socioeconomic status (Barker et al., 2011). High rates of diabetes prevalence are strongly associated with indicators of low socioeconomic status, poor environmental quality, and poor lifestyles (Green et al., 2003). Unsurprisingly, counties in the diabetes belt tend to be at lower levels of economic development (Barker et al., 2011).

Racial disparities in disease prevalence exist for nearly every disease in the United States. Diabetes is one of them. It is a chronic disease with many risk factors and severe complications, up to and including death. The increase in diabetes prevalence over the last couple of decades indicates that this is an issue that needs to be addressed. Further, the racial disparities in diabetes prevalence need to be more firmly understood to be able to address these disparities and reach the goal of the elimination of racial disparities in disease outlined by Healthy People 2020.

# 4 THE BUILT ENVIRONMENT

The built environment is an essential determinant of health. Where one lives has an effect on their health. Factors such as access to facilities can affect health. Arguably, residential segregation influences health. In fact, the built environment can be considered a fundamental cause of health disparities in the United States.

The built environment is an essential and unavoidable part of most humans' lives. The built environment, in short, concerns every human-designed and human-built facility in an area. Each area's built environment is contingent on several factors, including the area's natural resources, the affluence or poverty of the residents, and even the race or ethnicity of those who live there. Due to differences in natural and social factors throughout the environment, inequalities in the built environment exist in every community, from rural to urban, from wealthy to poverty-stricken, from predominately Caucasian to predominately minority communities. Inequalities in the built environment may underlie important ethnic and sociodemographic health disparities (Gordon-Larsen, Nelson, Page, & Popkin, 2006; Jackson, 2003). Understanding the causes of health disparities through the built environment is critical for improving health and reducing social inequality (Gordon-Larsen et al., 2006). Do differences in the built environment influence the health of the community? Do health disparities exist based on where a person lives and the resources that are available to them? These questions will be addressed in greater detail below.

## 4.1 Definitions

### *4.1.1 Defining the Built Environment*

What is the built environment? One of the common limitations of built environment research is that there are nearly as many definitions of the built environment as there are articles that address it. Overall, the built environment is the part of the physical environment made by people for people, including buildings, transportation systems, and open spaces (Northridge, Sclar, & Biswas, 2003). This may also include urban natural features, as most of them have been modified or created by humans as well. A popular definition of the built environment is all the characteristics of an area or neighborhood that cannot be reduced to the people who live in that area (de la Barra, 2000; Weich, Burton, Blanchard, Prince, Sproston, & Erens, 2001; Weich, Blanchard, Prince, Burton, Erens, & Sproston, 2002). Cohen, Inagami, & Finch (2008) state that the built environment is the way we design our communities and neighborhoods. Rood & Oleru (2008) define the built environment as "the human-made space in which people live, work, and recreate on a day-to-day basis", while Renalds, Smith, & Hale (2010) state it includes "all of the physical structures engineered and built by people—the places where we live, work, and play" (p. 24, p. 14). Sallis & Glanz (2006) define the built environment as "the totality of places built or designed by humans, including buildings, grounds around buildings, layout of communities, transportation infrastructure, and parks and trails" (p. 729). Woolf et al. (2013) bring health status into the definition, stating that "the built environment refers to the presence of (and proximity to) health-relevant resources as well as to aspects of the ways in which neighborhoods in which neighborhoods are designed and built" (Woolf et al., 2013, p. 195). This definition is most appropriate for this work because it includes health-related resources and one's accessibility to them. All references to the built environment in this study will use this definition of the built environment.

### *4.1.2 Other Definitions*

Another term important to this study is a health disparity population. It is defined as “a population where there is a significant disparity in the overall rate of disease incidence, prevalence, morbidity, mortality, or survival rates in the population as compared to the health status of the general population (National Institute of Health, 2000, p. 7). As this study is focused on determining the existence of health disparities in diabetes prevalence, this term is important to define clearly. Environmental health is defined by Healthy People 2010 as “compris[ing] those aspects of human health, disease, and injury that are determined or influenced by factors in the environment. This includes not only the study of the direct pathological effects of various chemical, physical, and biological agents, but also *the effects on health of the broad physical and social environment,* which includes housing, urban development, land-use and transportation, industry, and agriculture” (Srinivasan et al., 2003, p. 1446, emphasis mine).

## **4.2 The Built Environment and Overall Health**

Early research of place on health focused primarily on the eradication of infectious diseases (Lake & Townshend, 2006). It has only been since the early 1990s that researchers have had an increased interest in understanding both social inequalities in health as well as the overall importance of place in health (Diez-Roux, 2001; Diez-Roux, 2007). The resurgence of interest of place in health is due to several reasons, including interest in the social determinants of health, social influences on health that operate in many ways, and the growing use of ecologic variables in epidemiology (Diez-Roux, 2001).

Additionally, recent research into the intersectionality of sociology and public health has allowed the move from individual behaviors to broader proximate factors, such as racism and discrimination, and inequalities in access on health (Northridge et al., 2003). Relationships between place and health have been observed at a variety of spatial scales, from block and census tracts to states, regions, or even countries, for a variety of health outcomes (Bernard, Charafeddine, Frohlich, Daniel, Kestens, & Potvin, 2007). Neighborhoods have emerged as important because they possess physical and social attributes which could plausibly affect the health of individuals (Diez-Roux, 2007). The environment can be related to health through factors such as physical design, socio-cultural mores, and socioeconomic status (Lake et al., 2006). Additionally, environmental modifications can have an impact on the health of the population as well (Christian, Giles-Corti, Knuiman, Timperio, & Foster, 2011).

There are two different explanations for why neighborhoods influence health. The first is compositional. This explanation attributes the geographic clustering of health outcomes to the shared characteristics of residents (Bernard et al., 2007). In other words, people with similar health problems aggregate within geographic proximity. While this is possible (such as in the case of nursing homes or former leper colonies), in general it is rare. The second explanation is contextual, which attributes spatial variations in health outcomes in part to the characteristics of the environment itself (Bernard et al., 2007). This explanation is much more common, and forms the basis for this argument. In addition to these explanations, there are three pathways through which the environment's physical features may influence health. The first is environmental stressors such as housing conditions and neighborhood disorder. The second is health behaviors as influenced by options for outdoor activities, and the third is opportunities for social interactions and social integration (Northridge et al., 2003). These pathways can positively or negatively impact the health of residents in these areas.

The built environment can affect health in several ways. Specifically, it has been linked to negative effects regarding obesity, diet, and physical activity (Cohen et al., 2008; Ewing, Brownson, & Berrigan, 2006; Frank, Andresen, & Schmid, 2004; King, Belle, Brach, Simkin-Silverman, Soska, & Kriska, 2005; Lake et al., 2006; Li, Fisher, Brownson, & Bosworth, 2005; Morland, Wing, & Diez-Roux, 2002b; Sallis et al., 2006). The clear majority of adults do not meet weekly physical activity guidelines, and inactive lifestyles put people at risk for chronic diseases such as cardiovascular disease, diabetes, obesity, cancer and others (Sallis et al., 2006). The built environment features of neighborhoods, such as a lack of access to recreational facilities or healthy food, may be related to both obesity and obesity-related health disparities (Sallis et al., 2006). Higher density areas are more associated with walking and biking, while those living in sprawling counties are more likely to walk less, weigh more, and have a higher prevalence of hypertension (Dearry, 2004). Additionally, social factors of neighborhoods, such as neighborhood socioeconomic status and perceptions of neighborhood safety, has been linked to smoking habits, dietary patterns, blood pressure, high cholesterol, and higher body mass index (Diez-Roux, 2003a). There are racial disparities evident in health-related outcomes as well. For example, obesity, a major risk factor for diabetes, is particularly heightened in predominately minority communities (Duncan et al., 2012). Overall, the built environment affects food intake and energy expenditure, and weight gain and energy imbalance could be a function of both the built environment and its associated access to healthy options, such as supermarkets and recreational facilities, along with limited access to options such as alcohol outlets and fast food restaurants (Dearry, 2004; Frank, Kerr, Saelens, Sallis, Glanz, & Chapman, 2009).

## 4.3 Residential Segregation

Residential segregation is an integral part of the built environment. Although many researchers would argue that residential segregation is part of the social environment, I argue that residential segregation is a part of the built environment, because it serves as a mechanism by which place composition is associated with health. This is because the physical characteristics of the places where minorities live are drastically different than the places where Caucasians live. Access to facilities is limited in many minority communities, which as shown above, can affect health (Robert & Ruel, 2006). Thus, it makes sense to consider residential segregation as part of the built environment.

Segregation is “the physical separation of the races in residential contexts” (Williams et al., 2001, p.405). Residential segregation refers to the isolation of poor and/or racial minorities that live in neighborhoods isolated from other socioeconomic groups (Li, Campbell, & Fernandez, 2013). Segregated neighborhoods have persisted throughout the history of the United States. Today, racial segregation exists in various areas and institutions, and the systemic racism that segregation reveals is still not widely acknowledged in this country (Feagin, 2013). In general, African Americans live separately from Caucasian Americans and from most other Americans as well. Feagin (2014) discusses the index of dissimilarity, which details the evenness of how races exist in the US. Most central cities have an index of dissimilarity of 65 or more, meaning that 65% of African-American residents would have to move to predominately Caucasian areas to achieve evenness in racial composition.  Racial segregation exists in the suburbs as well (Feagin, 2014). Racial segregation in the housing market affects distribution of African-American employment, reduces job opportunities, and creates geographic separation and economic differences (Kain, 1968; Massey & Denton, 1993).

Residential segregation is more pronounced in the United States than in nearly every other country in the world (Cummins et al., 2006; Massey et al., 1993). African-Americans are far more segregated than any other ethnic or racial group living in cities (Williams et al., 2001). This segregation is particularly extreme in inner cities. Massey & Denton (1989) detail five dimensions of racial residential segregation. The first is evenness, which is the degree to which the percentage of minority members within residential areas equals the citywide minority percentage. Second is exposure, which is the degree of potential contact between minority and majority members. Third is clustering, which is the extent to which minority areas adjoin one another in space. Fourth is centralization, the degree to which minority members are settled in and around the center of an urban area. Fifth is concentration, which is relative amount of physical space occupied by a minority group (Massey et al., 1989; Massey et al., 1993). African-Americans experience extreme segregation on all the above dimensions in large urban areas. This is referred to as hypersegregation (Massey et al., 1989). As Massey et al. (1989, 1993) state, a high level of segregation on any of these dimensions is problematic because it isolates a minority group from opportunities, amenities, and resources that can affect social and economic well-being.

While the segregation of immigrants has generally declined, the segregation of African-Americans persists over time (Kain, 1968; Massey et al., 1993; Wilkes & Iceland, 2004; Williams et al., 2001). Immigrant segregation has never existed to the same extent as it is currently for African-Americans (Massey et al., 1993). Although overall segregation is declining, the level of segregation experienced by African-Americans is still significantly higher than any other population (Wilkes et al., 2004).

Minorities living in the suburbs has been increasing rapidly (Lleras, 2008). Unfortunately, minority suburbanization is often accompanied by racial segregation and increasing poverty (Lleras, 2008; Reardon & Yun, 2001). Further, despite declining racial segregation, poverty is suburbanizing and income disparities are growing wider (Li et al., 2013). African-American suburbanization can be misleading. While for many Caucasians, moving to the suburbs is associated with increased access to healthful facilities and better schools, for African-Americans moving to the suburbs can still mean living in areas characterized by extremely high poverty rates, and replication of issues of the inner city, including high crime rates and racial segregation (Massey et al., 1993).

Economic differences have been suggested as one of the reasons why racial segregation continues to persist in this country. However, this suggestion has for the most part been eliminated because if economic differences were the case, rich African-Americans would live with rich Caucasians, which rarely happens (Farley et al., 1994). Most researchers find instead that the majority of middle class African-Americans live in predominately African-American areas (Feagin & Sikes, 1994). Further, residential segregation in and of itself plays a key role in *maintaining* differences in socioeconomic status by race (Anderson, St. Charles, Fullilove, Scrimshaw, Fielding, & Normand, 2003; Lovasi et al., 2009; Massey et al., 1993). As Sampson et al. (1995) states, “macrosocial patterns of residential inequality give rise to the social isolation and ecological concentration of the truly disadvantaged, which in turn leads to structural barriers and cultural adaptations that undermine social organization" (p. 38). Robert et al. (2006) agree, stating that racial residential segregation both produces and reinforces the economic segregation of African-Americans in neighborhood contexts.

Another explanation for the persistence of residential segregation is based on discriminatory practices in real estate. Although the 1968 Civil Rights Act stated that housing segregation was no longer legal, there is evidence today that discriminatory practices still exist. Instead of blatant discrimination, segregation instead became more informal. Through factors such as discrimination and stereotyping, many African-Americans were unwilling to be pioneers in an all-Caucasian area (Farley et al., 1994). However, through realtor auditing, researchers have shown that discrimination by banking and lending institutions, along with racial steering among real estate agents, discourage African-Americans from moving into Caucasian areas, and vice versa (Farley et al., 1994). There are multiple means through which racial segregation in housing has been maintained, both legal (at one time) and extralegal (Kain, 1968). These include racial covenants, racial zoning (or redlining), using violence or threats of violence, preemptive purchases by Caucasians to keep African-Americans out of the neighborhood, petty harassment, collusion by realtors, banks, and mortgage lenders, the Federal Housing Authority and other federal agencies turning a blind eye to discriminatory practices, and block-busting practices (Kain, 1968; Krysan & Farley, 2002; Quadagno, 1994; Sampson et al., 1995). These practices can limit African-Americans' abilities to move into areas with a greater access to facilities such as supermarkets, parks, and healthcare facilities, which can negatively affect health.

### *4.3.1 Residential Segregation and Health*

Residential segregation by income, race, and ethnicity contributes to health disparities in the United States (Larson et al., 2009). Race-based residential segregation is a fundamental cause of racial disparities in health, isolating African-Americans in spatially distinct neighborhoods where their access to the resources necessary to maintain health is limited (Schulz et al., 2002; Williams et al., 2001). Fundamental causes of disease are those that involve access to the resources necessary to maintain health and avoid disease (Schulz et al., 2002). This is evidenced in that segregation influences access to social and material resources that promote health and avoid disease. Further, it promotes withdrawal of economic resources from older, racially segregated urban areas and reduces access to those resources essential to prevent disease and promote health, which in turn affects many health outcomes, both infectious and chronic (Bowser, 2007; Schulz et al., 2002). Race-based residential segregation as a fundamental determinant of health has been found to disproportionately expose African-Americans to the effects of concentrated poverty, as well as capturing the effects of institutional racism on health outcomes (Ruel & Robert, 2009; Schulz et al., 2002). This disproportionate clustering of African-Americans into very poor census tracts most likely contributes to racial disparities in health.

In general, there are two pathways through which racial segregation affects health. First, racial segregation may create an isolated environment that increases exposure to and perceptions of discrimination, leading to stressful situations. Residential segregation isolates people into specific areas and interferes with their ability to access healthful facilities, such as parks and grocery stores (Ruel et al., 2009; Ruel et al., 2010). Second, people in poorer health may be less likely to move out of segregated neighborhoods (Robert et al., 2006). These pathways create a composite of the contextual and compositional aspects of neighborhoods, described earlier. These situations may also influence the accessibility of healthful facilities in segregated neighborhoods. This study will examine the associations between segregation and access to facilities to determine whether this is the case.

### 4.4 Access to Facilities

Where we live determines what we are exposed to daily (Cohen et al., 2008). Due to common exposures, people who live in the same area are more alike than those who live in different areas. Exposures are a series of constraints or facilitators that actively play a role in our movements, successes, failures, relationships, and health (Cohen et al., 2008). Further, social determinants such as social status, income, education, occupation, and place of residence are significant determinants of life expectancy and health (Hartley, 2004). There are four aspects of neighborhoods that influence health. They include the physical features shared by all residents, the supportive environments to pursue health, quality services for all segments of the population, and sociocultural features reflecting neighborhood history (Bernard et al., 2007). As Bernard et al. (2007) states, “it is the crucial dimension of access, and the channels through which resources can be acquired and used, that our conceptualization of neighborhood highlights as a contributor of health inequalities” (p. 1841). All neighborhoods offer resources. The issue arises when neighborhoods have unequal resources, more negative than positive resources, or unequal access to resources. Availability and access to facilities and resources are regulated according to multiple dimensions, such as proximity, cost and affordability, accessibility, quality, rights, and informal reciprocity (Bernard et al., 2007; Frank, Glanz, McCarron, Sallis, Saelens, & Chapman, 2006; Gordon-Larsen et al., 2006). These dimensions are influenced by households, businesses, property owners, and local government (Bernard et al., 2007).

### 4.4.1 *Geographic Access*

There are many different types of access to facilities and resources. One major type is geographic access. Numerous studies show that living in urban, suburban, or rural areas affects one's health (de la Barra, 2000; Dearry, 2004; Frist, 2005; Hartley, 2004; Kain, 1968; Northridge et al., 2003; Renalds et al., 2010; Sallis et al., 2006; Srinivasan et al., 2003; Wilson, 1996). Nowadays, nearly eighty percent of North Americans live in metropolitan statistical areas—urban agglomerations of towns and cities of 50,000 people or more (Northridge et al., 2003; Srinivasan et al., 2003). De la Barra (2000) states that "cities are the physical expression of the societies that build them, and the political, social, and economic interactions of their inhabitants" (p. 7). What is interesting about urban areas is their juxtaposition of health outcomes. Higher density areas are more associated with walking and biking, and people who live in urban areas report more physical activity than those living in suburban or rural areas (Dearry, 2004).

Although many disadvantaged areas exist in the central city, rural areas are subject to health issues all their own. In fact, Hartley (2004) states that there may be environmental and cultural factors unique to towns, regions, or USDA economic types that affect health behavior and health. Opposite of urban areas, those living in sprawling counties with small populations are more likely to weigh more, walk less, and have a higher prevalence of hypertension (Dearry, 2004). In fact, rural residents are at a high risk of multiple poor health outcomes due to worse health behaviors (Sallis et al., 2006). Rural residents tend to smoke more, exercise less, have less nutritional diets, and are more likely to be obese than other residents (Hartley, 2004). However, these health behaviors have all been correlated with income and education, and may be more influenced by those factors than by rural residence (Hartley, 2004). Rural residents who live in the southern United States have higher rates of poverty, smoking, physical inactivity, death due to heart disease, and teen births (Hartley, 2004). Further, rural areas rank poorly on population health indicators such as the health behaviors mentioned above, as well as mortality, morbidity, and maternal and child health (Hartley, 2004). Unfortunately, in areas with consistently lower wages and low economic influence, economic development is much more likely to trump healthy design (Hartley, 2004). Finally, residents of rural neighborhoods are most often affected by poor access to facilities such as supermarkets (Larson, Story, & Nelson, 2009).

The growth of suburbia exploded in the mid-twentieth century, but has slowed in recent years (Wilson, 1996). Compared to those living in urban or rural areas, those living in suburban areas tend to be healthier (Hartley, 2004). Access to health facilities, including healthcare facilities, supermarkets, and parks and recreational facilities tends to be higher for suburban areas compared to rural areas. However, there are some negative factors associated with living in suburban areas. Like rural residents, suburban residents who live in sprawling areas tend to perform less physical activity and to have a higher body mass index (BMI). Further, long commutes lead to an increase in sedentariness (Renalds et al., 2010). In conclusion, while suburban areas tend to have greater access to health facilities, the residents are still susceptible to health issues, including low physical activity and obesity.

Regardless of geographic location, disadvantaged groups tend to live in worse environments with respect to food stores, places to exercise, aesthetic issues, and other facilities. There are disparities in access regarding socioeconomic status and race. For example, Williams & Collins (2001) found that there was unequal access to services provided by the tax dollars paid in African-American neighborhoods. The disparities in access to facilities based on race, income, and socioeconomic status will be lined out in greater detail below.

The built environment of any community has features that promote energy expenditure through physical activity and energy intake through the presence of food stores (Duncan et al., 2012). A few years ago, a systematic review of the built environment and health found that most studies examined the following metrics of access to facilities: population density, density of fast food restaurants, full service restaurants, convenience stores, grocery stores, and county sprawl index (Feng, Glass, Curriero, Stewart, & Schwartz, 2010). According to built environment studies, researchers found the strongest support for the importance of food stores, exercise facilities, and safety as the most important characteristics of the built environment (Lovasi et al., 2009). Access to food outlets, parks and recreational facilities, pharmacies, alcohol stores, and others have been linked to health as well (Cohen et al., 2008). The exposure to poor quality food and physical activity environments amplifies individual risk factors for health issues, such as diabetes and obesity (Cummins & Macintyre, 2006). In fact, the most disadvantaged neighborhoods are the most likely to have the highest rates of obesity, which is a major risk factor for diabetes. These neighborhoods face a paradox of hunger and obesity, because residents in poor neighborhoods tend to consume energy dense inexpensive foods, such as processed and frozen foods high in carbohydrates and sodium (Cummins et al., 2006). These types of neighborhoods are obesogenic, defined by Lake et al. (2006) as “the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals and populations” (p. 262). There is a robust association of lower income and higher food insecurity with lower intakes of fruits and vegetables (Cummins et al., 2006). Both negative and positive aspects of the built environment exist in every community. I will outline the major facilities below along with the literature associated with them.

### 4.4.2 *Positive Food Environment Variables*

#### 4.4.2.1 Food Stores

Food stores constitute one of the most important built environment features that affect health in a community. Safe and convenient access to healthy food is a fundamental environmental justice concern, but it can also be linked to individual dietary behavior and health issues (Frank et al., 2006). The price and the availability of healthy foods is a major mediating factor between environment, diet quality, and obesity (Cummins et al., 2006; Morland et al., 2002b). According to other studies, cost is a significant predictor of dietary choices (Morland, Wing, Diez-Roux, & Poole, 2002a; Schulz et al., 2002). Residents in low-income areas tend to buy more energy-dense foods in smaller quantities (Morland et al., 2002a). In general, because poorer areas have lower access to supermarkets and higher access to convenience stores, fast food outlets, and smaller grocery stores, food costs more and residents spend a greater proportion of their income on food in these areas.

There are three major types of food stores: supermarkets, grocery stores, and convenience stores. Of course, other types of stores do exist, such as bakeries, fish markets, farmer's markets, etcetera, but overall, most types of stores that provide food can be broken down into one of these three major categories. Chain supermarkets account for 84% of all total sales among all food stores, while supermarkets and grocery stores combined sell 92% of the total volume of annual sales of all food and beverage stores in the United States (Morland et al., 2002b). Of all types of food stores, supermarkets tend to offer the greatest variety of high-quality products at the lowest cost (Larson et al., 2009). Supermarkets have a larger selection of healthy food, higher quality of food, and lower costs (Crockett, Clancy, & Bowering, 1992; Curtis & McClellan, 1995; Hall, 1983; Kaufman, MacDonald, Lutz, & Smallwood, 1997; Mantovani, Daft, Macaluso, Welsh, &

Hoffman, 1997; Morland et al., 2002b; Morris, Neuhauser, & Campbell, 1992; Sallis, Nader, & Atkins, 1986; Williams et al., 2001; Zenk, Schulz, Hollis-Neely, Campbell, Holmes, Watkins, …, & Odoms-Young, 2005b). Supermarkets also have twice the number of heart healthy foods than neighborhood grocery stores and four times more than convenience stores (stores that sell predominately prepackaged, processed food) (Morland et al., 2002a).

There is a consistent association between proximity to a grocery store and more healthful diets (Frank et al., 2006; Morland et al., 2002b). The ability to meet the recommendations for a healthy diet is associated with the nearby presence of a supermarket. Individual interventions are, in general, not broad enough to affect general changes in dietary behavior (Morland et al., 2002a). Research results suggest that neighborhood residents who have better access to supermarkets, greater access to physical activity facilities, and limited access to convenience stores and fast food restaurants tend to have healthier diets and lower levels of obesity (Grier & Kumanyika, 2008; Harris, Pomeranz, Lobstein, & Brownell, 2009; Institute of Medicine, 2006; Lake et al., 2006; Larson et al., 2009). Neighborhood residents with better access to supermarkets have better food intakes, and there is a direct relationship between having at least one supermarket in an area and meeting the Health and Human Services dietary guidelines for fruit and vegetable intake (Larson et al., 2009). Closer proximity to a chain supermarket is positively associated with vegetable intake and overall dietary quality (Laraia, Siega-Riz, Kaufman, & Jones, 2004; Morland et al., 2002b; Wrigley, Warm, Margetts, & Whelan, 2002; Zenk et al., 2005b). Some results show that these results differ by race. For African-Americans, fruit and vegetable intake increased by 32% for each additional supermarket in a census tract, while Caucasian Americans' fruit and vegetable intake increased by 11% (Morland et al., 2002b). Conversely, inadequate accessibility to supermarkets can contribute to less nutritious diets and a greater risk of chronic diet-related diseases, such as obesity and diabetes (Zenk, Schulz, Israel, James, Bao, & Wilson, 2005a). These differences in access to food may have a significant influence on health disparities (Larson et al., 2009).

Over the last half century, there has been a migration of supermarkets from urban to suburban areas (Moore et al., 2006; Morland et al., 2002a). The exodus of major grocery stores and other retail outlets from high poverty and high minority areas forces the residents who are left behind to shop in the small convenience stores, smaller grocery stores, and liquor stores that are available in their community (Schulz et al., 2002). These facilities are characterized by limited selections, poorer quality, higher prices, and a lower likelihood of access to pharmacies and needed medications. Further, some studies have shown that even among stores of the same type, those in lower-income areas have less availability, more limited selection, and higher prices of foods for sale (Zenk et al., 2005b). Overall, research suggests that healthy foods are less available in deprived communities compared to ones that are more affluent (Diez-Roux, 2003a; Frank et al., 2006).

Supermarkets are more likely to be located in wealthier and predominately Caucasian areas (Dearry, 2004; Diez-Roux, 2003a). In these areas, there are on average five times more supermarkets than in predominately minority or lower socioeconomic status areas. These areas also contain more full-service restaurants and fewer small grocery stores (Morland et al., 2002b). Conversely, access to supermarkets and grocery stores is constrained for those who live in low-income or predominately African-American neighborhoods (Dearry, 2004; Frank et al., 2006; Larson et al., 2009; Morland et al., 2002b; Ruel, Reither, Robert, & Lantz, 2010; Srinivasan et al., 2003; Zenk et al., 2005a; Zenk et al., 2005b). In the average African-American neighborhood, a supermarket serves 23,582 residents, whereas in Caucasian neighborhoods, the average supermarket serves only 3,816 residents (Morland et al., 2002a). In African-American neighborhoods, the nearest supermarket was over a mile further away than in Caucasian neighborhoods (Larson et al., 2009; Zenk et al., 2005a). Additionally, only 8% of African-Americans live in a census tract with at least one supermarket, compared to 31% of Caucasian Americans (Morland et al., 2002b). Poorer neighborhoods have less access to supermarkets (half the access) but greater access to smaller grocery stores and convenience stores (four times the access) (Lovasi, et al. 2009; Moore et al., 2006).

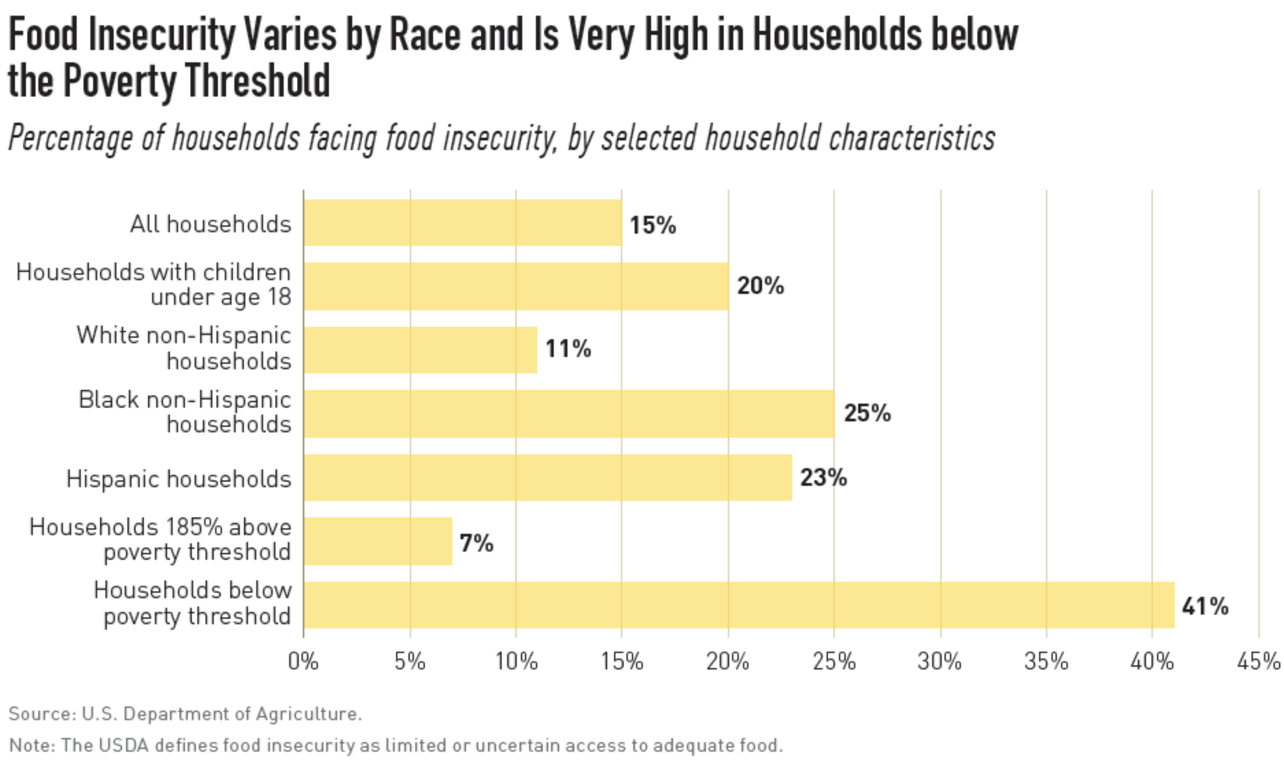


**Figure 4.1. Food Insecurity by Race and Poverty. Source: Urban Land Institute, 2013.**

Health issues related to food insecurity are exacerbated by the above disparities in healthy food access. Figure 4.1 demonstrates how food insecurity varies by race and is very high in households below the poverty threshold. Paradoxically, areas with a higher food insecurity tend to have residents who are more obese. However, there is a simple explanation as to why this is. Healthier foods are generally more expensive (Cummins et al., 2006). Poorer minority areas tend to have fewer fruit or vegetable markets, bakeries, and natural food stores (Morland et al., 2002b). Further, poorer people spend a greater proportion of their money on food, and a logical focus is to buy food that fills one up, rather than what may be healthy (Morland et al., 2002b). Some studies have shown that introducing a supermarket into a neighborhood increases both fruit and vegetable consumption, due to greater accessibility and lower cost of food (Cummins et al., 2006; Dearry, 2004).

There are a couple of complexities in examining the food environment. First, it is nearly impossible to disentangle the types and number of stores available from the actual foods offered for sale at the stores (Diez-Roux, 2003a). Many researchers who study the food environment assume that supermarkets have the greatest selection of healthy food at lower prices, but this may not be true everywhere. One study, conducted in Atlanta, surveyed the inventory of food stores in different socioeconomic strata and racial composition. They found that while researchers tend to make the above assumption, it does turn out to be generally true. Supermarkets do tend to have greater quality of food at lower prices, especially in Caucasian, more affluent areas (Frank et al., 2006). Second, cultural factors may play a role in shaping community food consumption (Diez-Roux, 2003a). Some cultures celebrate food that is higher in fat and calories, while others may not. Both characteristics make it difficult, though not impossible, to accurately study the food environment.

### *4.4.3 Negative Food Environment Variables*

#### 4.4.3.1 Alcohol Outlets

The presence of alcohol outlets in an area generally constitute negative aspects of the built environment. Individual characteristics and alcohol use are well-documented (Bernstein, Galea, Ahern, Tracy, & Vlahov, 2007). On average, alcohol use varies by race and gender. Non-Caucasians tend to have more negative attitudes toward drinking and drunkenness. Alcohol use in the United States is associated with being male, Caucasian, unmarried, lower income, lower education, lower employment, and younger age (Bernstein et al., 2007). Further, neighborhoods that are Caucasian and affluent tend to have increased parental drinking which may be associated with increased alcohol use (Bernstein et al., 2007; Chuang, Ennett, Bauman, & Foshee, 2005). With the information provided by the demographic characteristics of alcohol use, it is therefore interesting that urban, minority neighborhoods have a disproportionate share of alcohol advertising and availability (Bernstein et al., 2007). There are several studies that have examined the spatial relationships between alcohol use and the availability of alcohol (Bernstein et al., 2007; Cohen, Ghosh-Dastidar, Scribner, Miu, Scott, …, & Brown-Taylor, 2006; Gorman, Speer, Gruenewald, & Labouvie, 2001; Gruenewald, Ponicki, & Holder, 1993; Gruenewald, Remer, & Lipton, 2002; Lipton & Gruenewald, 2002; Millar & Gruenewald, 1997; Zhu, Gorman, & Horel, 2004). Further, the overall density of alcohol outlets is highly correlated with tract disadvantage. Overall, there are more liquor stores in poor and minority neighborhoods (Cohen et al., 2008; Moore & Diez-Roux, 2006). The availability of alcohol at different places where people may drink affects drinking practices and shapes the incidence, prevalence, and geographic distribution of alcohol-related problems in the community (Gruenewald et al., 2002).

#### 4.4.3.2 Convenience Stores

Compared to supermarket studies, there is relatively little research on the placement of convenience stores and their inventory of food products. What is known about convenience stores indicates that the food selection is of lesser quality and more expensive than supermarkets, but may be more accessible in low-income areas.  Low-income urban neighborhoods often have a greater number of convenience stores and a lower number of grocery stores or supermarkets than high-income suburban neighborhoods (Frank et al., 2006). This translates into lower access to supermarkets for poorer areas, and thus less access to quality healthy food (Lovasi et al., 2009; Moore et al., 2006). The greater density of convenience stores in poor areas influences not only access to food, but also the cost of food (Frank et al., 2006). Convenience stores tend to sell mostly prepared, high calorie foods and little fresh produce at higher prices (Larson et al., 2009). Compared to supermarkets, convenience and small grocery stores have produce that is of poorer quality and more expensive (Lovasi et al., 2009). Unfortunately, convenience stores and corner markets are often the only food sources in poorer areas (Urban Land Institute, 2013). Because the lack of selection and higher prices of food at convenience stores, greater access to these places is associated with an increased risk of obesity (Larson et al., 2009). The same is true for fast food restaurants.

#### 4.4.3.3 Fast Food Restaurants

In the last several decades, there has been a societal shift away from home food consumption (Frank et al., 2009). Americans in general are eating more fast food (food that is prepared quickly, in restaurants where people pay before consumption) than ever before. However, there are several health concerns associated with eating fast food. There is a positive association with fast food outlets in terms of obesity (Christian et al., 2011; Diez-Roux, 2003a;

Lake et al., 2006; Li et al., 2009). Fast food and restaurant meals tend to be more calorie dense and of poorer nutritional quality than foods consumed at home (Larson et al., 2009). Portion sizes are larger, and can be up to 65% more energy dense than the average diet (Cummins et al., 2006). A higher frequency of fast food consumption is related to poor dietary quality, weight gain, and a higher BMI (Frank et al., 2009; Renalds et al., 2010). Only one study did not show a consistent relationship between fast food and obesity (Feng et al., 2010). Fast food restaurants are considered a negative aspect of the built environment, due to the multiple negative health issues associated with fast food consumption (Cohen et al., 2008). In high density fast food restaurant neighborhoods, residents who ate at these places once to twice weekly were almost twice as likely to be obese than those who lived in low density fast food neighborhoods (Li et al., 2009). Conversely, residents with limited access to fast food restaurants tend to have healthier diets and lower levels of obesity (Larson et al., 2009).

There are racial disparities in fast food access. This is a matter of concern, as fast food restaurant access is associated with negative health factors such as obesity. The number of fast food restaurants nationwide has increased significantly over the past couple of decades, but most particularly in low-income and predominately African-American urban neighborhoods (Block, Scribner, & DeSalvo, 2004; Duncan et al., 2012; Farley, Steeh, Krysan, Jackson, & Reeves, 1994; Li et al., 2009; Powell, Chaloupka, & Bao, 2007). As stated above, poorer neighborhoods have less access to supermarkets but a greater access to fast food and convenience stores, strongly restricting residents' access to healthy, inexpensive foods (Lovasi et al., 2009).

### *4.4.4 Healthcare Facilities*

Finally, healthcare facilities are another aspect of the built environment with racial disparities in access. There is relatively little research on disparities in access to healthcare and quality medical care, but what does exist unequivocally states that when minorities are denied access to healthcare facilities, their health tends to suffer (Frist, 2005). Along with food stores, alcohol outlets, and recreation centers, disparities in access exist. There are racial disparities, socioeconomic disparities, and geographical disparities in healthcare access (Frist, 2005). In disadvantaged areas, healthcare facilities are either of low quality or do not exist at all (Williams et al., 2001). Those that do exist are more likely to close, less likely to have adequate medication, and residents are less likely to receive appropriate medical care (Williams et al., 2001). One study examined disparities in healthcare access from another point of view. LaViest, Thorpe, Galarraga, Bower, & Gary-Webb (2009) conducted a comparison between segregated and integrated neighborhoods and found that when African-Americans and Caucasians access similar healthcare facilities, their health outcomes are more similar. Thus, having access to healthcare facilities is of utmost importance of maintaining the health of residents. Only when healthcare access is evenly distributed throughout all neighborhoods will we see a decrease in racial, socioeconomic, and geographic disparities in health.

### *4.4.5 Physical Activity Facilities*

#### 4.4.5.1 Recreation Facilities

Healthy People 2020 and the Institute of Medicine identify parks and recreation facilities as providing physical activity settings (Sallis et al., 2006). Parks and other types of recreational facilities are positive aspects of the built environment (Cohen et al., 2008). The built environment affects energy balance by presenting opportunities or barriers for physical activity

(Feng et al., 2010). Lack of physical activity is a growing health problem in the United States (McNeill, Kreuter, & Subramanian, 2006). There is an inverse association between the presence of recreational facilities and obesity (Christian et al., 2011; Gordon-Larsen et al., 2006). Increasing the number of recreational facilities in an area is associated with decreased overweight and obesity and increased relative odds of achieving more physical activity. People living in areas with greater access to physical activity facilities tend to have a lower BMI. Further, the walkability of neighborhoods can impact physical activity in a community. High walkability and the mixed use of neighborhoods has been associated with an enhanced sense of community and social capital (Diez-Roux, 2003b; Houston, Basolo, & Yang, 2013). Conversely, less walkable areas lead to obesogenic environments (Lake et al., 2006).

Access to recreation centers for physical activity is an extremely important aspect of the built environment. Accessibility of recreation facilities is defined as the presence of recreational facilities and the distances to them (Diez-Roux, 2003a). Along with walkability, having ready access to facilities is positively associated with increased physical activity and lower obesity rates (Gordon-Larsen et al., 2006; Sallis et al., 2006). Conversely, studies have shown that people who do not have access to recreation centers tend to lead more sedentary lives in their leisure time (Lovasi et al., 2009).

Racial disparities exist when it comes to access to recreational facilities. Gordon-Larsen et al. (2006) show that all major categories of physical activity related resources (such as parks or recreation centers) are inequitably distributed, with high-minority, lower-educated neighborhoods at a strong disadvantage. Even facilities that are expected to be distributed equally (such as government-maintained parks, YMCAs, and schools) are not as readily available in disadvantaged areas. Because low-income residents perceive less access to indoor and outdoor places to exercise, they tend to walk around shopping malls, while higher income residents are more likely to use treadmills or other exercise equipment available at gyms and recreational facilities (Lovasi et al., 2009). This relationship is linear. The relative odds of having at least one recreation facility decreases as minority population increases (Gordon-Larsen et al., 2006). In fact, individuals living in high minority and poor areas are only half as likely as those living in Caucasian and more affluent areas to have a recreation facility (Gordon-Larsen et al., 2006; Renalds et al., 2010; Sallis et al., 2006). This inequality in availability of recreational facilities may contribute to racial and socioeconomic disparities in physical activity and overweight patterns (Gordon-Larsen et al., 2006).

### 4.5 Challenges in Studying the Built Environment

As shown in the previous sections, the built environment that one lives in is of utmost importance to one's health. The locations of alcohol outlets, food stores, fast food restaurants, recreation centers, and healthcare facilities have all been shown to be inequitably distributed in the American landscape. Racial, socioeconomic, and geographic disparities exist for all aspects of the built environment, and ready access to negative aspects (such as alcohol outlets and fast food restaurants) and limited access to positive aspects (such as supermarkets and recreational facilities) have been shown to negatively affect health. To address the disparities inherent in the built environment, it is imperative that the built environment is studied and measured accurately and consistently. However, there are several challenges in studying the built environment.

The first challenge involves the distribution of the American population. In recent years, there has been a growth in 'megalopolises,' or super urban regions. In the United States, the ten largest consolidated metropolitan statistical areas account for one third of the entire population (Northridge et al., 2003). This makes research into particular neighborhoods difficult, and leads to ambiguity in what constitutes an urban or a suburban region. Often, researchers will define geographic density with their own population markers, which is difficult to replicate across studies (Northridge et al., 2003).

Another challenge, related to the first, involves the definition of neighborhoods or other relevant geographic areas. This is difficult because there are nearly as many definitions of neighborhoods as there are researchers who study them. In fact, Diez-Roux (2001) describes neighborhoods as the "geographic area whose characteristics may be relevant to the specific health outcome being studied" (p. 1784). While health research often uses neighborhood and community to refer to a person's immediate residential environment, the criteria and concepts themselves are not precise (Diez-Roux, 2001; Larson et al., 2009). While a neighborhood may be geographically anchored, criteria for inclusion into a neighborhood can be historical (such as for previous environmental hazards, such as a chemical spill), administrative (areas affected by policies or politics), or a researcher's or participant's subjective perception (such as social interaction or social cohesion) (Diez-Roux, 2001). The relevance of a neighborhood may be different for different types of studies. For example, a study involving education may examine school districts for child outcomes, or a researcher may use neighborhoods previously determined in a national dataset (Diez-Roux, 2001). Many characteristics of nearby neighborhoods may be interrelated.

The final challenges in studying the built environment are ones common in other sociological research. Researchers should be aware of and avoid potential reductionism or simplification when using neighborhoods as a proxy for individuals. Secondly, there are multiple upstream and downstream determinants that can affect one's health beyond one's neighborhood. Third, the effects found in a neighborhood may be small in comparison to the individual-level effect of being a member of a disadvantaged group. Finally, there are other contexts (such as church or work) which may be more salient to an individual than their neighborhood (Diez-Roux, 2001).

### 4.6 Hypotheses

This study seeks to determine whether the built environment and neighborhood composition influence diabetes prevalence. As stated in the introduction, this study will attempt to answer two predominant questions. I have grouped the hypotheses based on which overarching question each attempts to answer. First, how does neighborhood composition affect one's built environment? The first three hypotheses address this first question. I hypothesize that, for the state of Georgia, the built environment will vary based on the racial makeup of the residents who live there. I predict that areas of higher minority concentration will have lower access to healthful facilities and a higher access to harmful facilities (such as alcohol outlets and fast food restaurants). Secondly, I hypothesize that the built environment will vary based on the income makeup of the residents. I predict that areas of lower income will have a less desirable built environment, in terms of access and availability of healthful facilities. Third, I hypothesize that the built environment will vary based on the geographic density of the areas where people live.

**Table 4.1. Hypotheses Tested.**

1. **How does neighborhood composition influence the built environment?**
    a. **The built environment will decline as African-American presence in a county increases.**
        i. **The proportion of positive food outlets will decrease as African-American presence increases.**
        ii. **The proportion of negative food outlets will increase as African-American presence increases.**
        iii. **The proportion of healthcare facilities will decrease as African-American presence increases.**
        iv. **The proportion of physical activity facilities will decrease as African-American presence increases.**
        v. **The proportion of public administration facilities will decrease as African-American presence increases.**
    b. **The built environment will improve as the neighborhood disadvantage scale decreases at the county level.**
        i. **The proportion of positive food outlets will increase as neighborhood disadvantage scale decreases.**
        ii. **The proportion of negative food outlets will decrease as neighborhood disadvantage scale decreases.**
        iii. **The proportion of healthcare facilities will increase as neighborhood disadvantage scale decreases.**
        iv. **The proportion of physical activity facilities will increase as neighborhood disadvantage scale decreases.**
        v. **The proportion of public administration facilities will increase as median household income increases.**
    c. **The built environment will be better in urban areas and worse in rural areas at the county level.**
        i. **The proportion of positive food outlets will be greater in urban areas than in rural areas.**
        ii. **The proportion of negative food outlets will be lesser in urban areas than in rural areas.**
        iii. **The proportion of healthcare facilities will be greater in urban areas than in rural areas.**
        iv. **The proportion of physical activity facilities will be greater in urban areas than in rural areas.**
        v. **The proportion of public administration facilities will be greater in urban areas than in rural areas.**
2. **How do neighborhood composition and built environment together influence diabetes prevalence?**
    a. **Areas of higher African-American presence will have lower access to healthful facilities and a higher prevalence of diabetes.**
        i. **Areas of higher African-American presence will have lower access to positive food outlets and a higher prevalence of diabetes.**

**ii. Areas of higher African-American presence will have higher access to negative food outlets and a higher prevalence of diabetes.**
**iii. Areas of higher African-American presence will have lower access to healthcare facilities and a higher prevalence of diabetes.**
**iv. Areas of higher African-American presence will have lower access to physical activity facilities and a higher prevalence of diabetes.**
**v. Areas of higher African-American presence will have lower access to public administration facilities and a higher prevalence of diabetes.**

**b. Areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes.**
**i. Areas that are poorer will have lower access to positive food outlets and a higher prevalence of diabetes.**
**ii. Areas that are poorer will have higher access to negative food outlets and a higher prevalence of diabetes.**
**iii. Areas that are poorer will have lower access to healthcare facilities and a higher prevalence of diabetes.**
**iv. Areas that are poorer will have lower access to physical activity facilities and a higher prevalence of diabetes.**
**v. Areas that are poorer will have lower access to public administration facilities and a higher prevalence of diabetes.**

**c. Areas that are rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes.**
**i. Areas that are rural will have lower access to positive food outlets, which will be associated with a higher prevalence of diabetes.**
**ii. Areas that are rural will have higher access to negative food outlets, which will be associated with a higher prevalence of diabetes.**
**iii. Areas that are rural will have lower access to healthcare facilities, which will be associated with a higher prevalence of diabetes.**
**iv. Areas that are rural will have lower access to physical activity facilities, which will be associated with a higher prevalence of diabetes.**
**v. Areas that are rural will have lower access to public administration facilities, which will be associated with a higher prevalence of diabetes.**

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How do neighborhood composition and built environment combined affect diabetes prevalence? The second overarching question will encompass the last three hypotheses. I predict that access to healthful opportunities will be limited in low-income, high minority areas. I also predict that urban areas will have greater access to healthful facilities, such as supermarkets, physician's offices, and parks than rural areas. As access to healthful opportunities increases, the prevalence of diabetes decreases. Further, access to unhealthful options will be abundant in low-income, high minority areas, and as access to these facilities increases, the prevalence of diabetes will increase as well. Fourth, I hypothesize that areas of higher minority racial residential segregation will have lower access to healthful facilities and a higher prevalence of diabetes. Fifth, I predict that areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes. Finally, I hypothesize that areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes.

I will examine these hypotheses through the theoretical framework of fundamental causes and through the pathway shown in Figure 4.2. Based on the literature, the composition of neighborhoods, whether they are subject to residential segregation and/or urban or rural location, influence the availability of healthful facilities, such as supermarkets, parks, recreation facilities, and healthcare facilities. This accessibility to facilities affects residents' diets, physical activity, and propensity to visit doctors' offices. Finally, these health behaviors affect diabetes prevalence. I argue that differential composition of neighborhoods, in this way, leads to differential access to facilities, leading to differential health behaviors, which leads to diabetes disparities.

Racial disparities exist in diabetes prevalence throughout the United States (LaViest et al., 2009). However, very little research has focused on the potential effect that one's physical environment may have on the prevalence of diabetes in the community. In recent years though, there has been an increasing popularity and availability of methods especially suited to the study of neighborhood health effects (Diez-Roux, 2003b). Specifically, the use of geographic information systems (GIS) and spatial analysis techniques has become more popular in the last couple of decades (Diez-Roux, 2007).

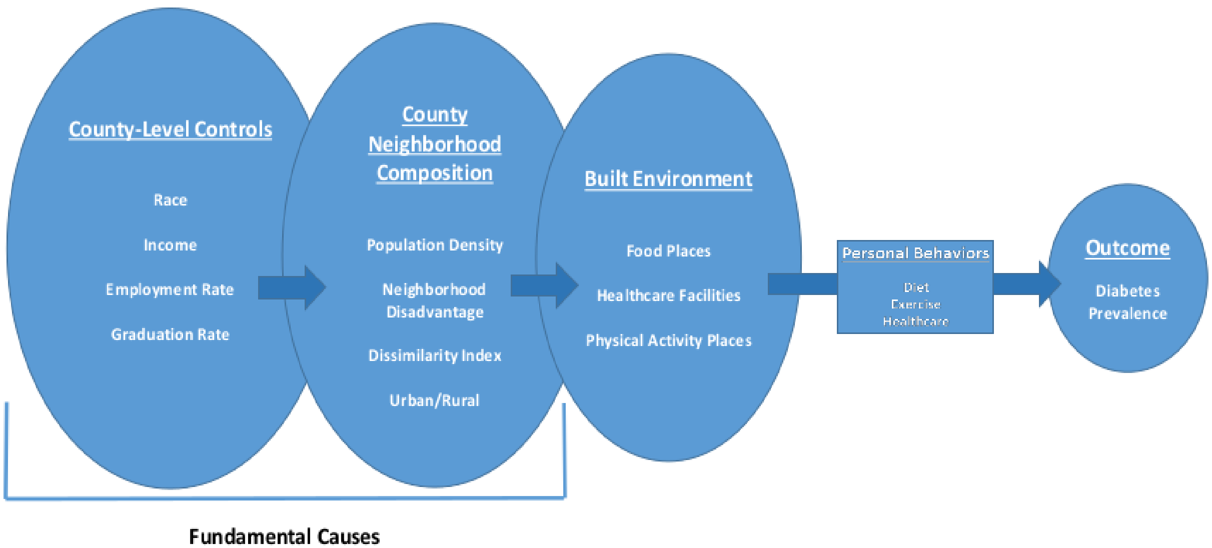



**Figure 4.2. Pathway by which the Composition of Neighborhoods affects Diabetes Prevalence.**

In the next section, I describe the ways that I will examine the relationship between one's built environment and access to resources and the prevalence of diabetes. To do so, I will conduct multiple analyses using variables derived from several sources.

# 5 METHODS AND PLAN OF ANALYSIS

To describe the study design, first I discuss the sample and the data sources from which the sample of residents was drawn. The survey described below covers the residents and their health, including their overall risk of diabetes as well as the prevalence of the disease in geographic terms. Next, I identify and describe the source for the built environment assessment. This shows the locations of various health opportunities for residents, including food stores, hospitals, medical offices, and physical recreation facilities. Finally, I explain the source of the demographic data, the American Community Survey (ACS), in greater detail below.

Once I have explained the sources of data, I will go into further detail about the constructs and variables that were used in these analyses. These include the dependent variable of the prevalence of diabetes at the county level and the independent variables of sociodemographic factors, dissimilarity index, neighborhood disadvantage scale, and population density to the density of locations that can affect health.

Finally, I will delve into the study design itself. First, the information from the survey below was collected. I will go into some detail of the methods involved in creating county-level estimates for health outcomes from surveys designed to be representative at the state level. Next, with the information from the built environment data collection, I mapped the coordinates of all relevant health-related facilities throughout Georgia. I then conducted a geospatial analysis using both descriptive and more advanced techniques. This is stratified by race, income, and geographic density to determine whether geographic and racial disparities in access to both positive and negative health facilities is associated with differences in the prevalence of diabetes in residents in the state of Georgia.

## 5.1 Population

The population of interest for this study are all residents of the state of Georgia, aggregated to the county level (n=159). At the county level, the demographic information about residents comes predominately from the ACS. The built environment data was gathered using Reference USA (www.referenceusa.com). This information includes addresses and geographical coordinates for resources such as supermarkets, medical facilities, and recreation facilities. Finally, information about diabetes status aggregated to the county level was derived from a national health survey, the Behavioral Risk Factor Surveillance System (BRFSS).

## 5.2 Data Sources

The BRFSS is a major data collection program of the Centers for Disease Control and Prevention (CDC) (Behavioral Risk Factor Surveillance System, 2014). It was initiated in 1984 and is a cross-sectional survey conducted in waves monthly, but reported annually. The survey is designed to be representative at the state level (BRFSS 2014, SAE n.d.). The population of interest for this survey is US noninstitutionalized adult residents, and it is used to collect prevalence data regarding risk behaviors that can affect health. The purpose of the BRFSS is to provide states, health departments, and other organizations with risk data that, combined with mortality and morbidity statistics, can inform health policy (BRFSS, 2014). The BRFSS's sampling strategy is determined by and implemented at the state level. States may decide to sample by county, census tract, or some other designation (BRFSS, 2014). Once the sampling strategy is decided, the state receives a sample of residents from the CDC. Landline telephone samples are determined through disproportionate stratified sampling, while the cell phone sample is gained through a simple random sample (BRFSS, 2014). The sample size for the BRFSS is roughly 200,000 for the entire nation.

The BRFSS has several advantages and disadvantages. Its first advantage is that it has a very large sample size. The sample size averages 200,000 respondents per year (Parsons et al., 2008; Raghunathan et al., 2007). The second major advantage is that the BRFSS provides a sample for 99% of all counties in the United States. However, there are a few disadvantages of using the BRFSS over other health surveys. The first drawback is that the respondents are contacted by phone, and the sample includes only households with telephones, either cellular or landline. A phone-only sample could lead to bias, as those without phones are not represented and this absence could significantly affect the results. Those living in disadvantaged areas may not have access to a home phone or cell phone. Thus, the results of this research could be understated, due to lack of access to these residents. However, the National Center for Health Statistics (NCHS) shows that, as of 2015, over 98% of Americans have either a home phone or cell phone, so this potential bias may not be as serious as it would have been in years past (NCHS, 2015)

Along with sample bias, system biases are introduced, because there are fifty-one different surveys branded as the BRFSS (Parsons et al., 2008). However, if a researcher was looking at the data in only one state (as in this case), this drawback is moot. A third drawback is that while most counties are represented, many only have a very small sample size, which limits generalization for those areas (Parsons et al., 2008). Finally, one of the largest disadvantages of using the BRFSS is its relatively low response rate. Each year, the BRFSS averages only about a 50% response rate (BRFSS Combined Landline and Cell Phone Weighted Response Rates by

**Table 5.1. Brief description of the BRFSS survey data collection style.**

| | BRFSS |
|---|---|
| **Coverage** | Residential households with landline telephones |
| **Type of Collection** | Face-to-face |
| **Response Rate** | ~50% |
| **Sample Size** | ~35,000 households |
| **Sample Strategy** | Multistage cluster sample |

State, 2011; Parsons et al., 2008; Raghunathan et al., 2007). Please see Table 5.1 for a concise description of the BRFSS survey.

To determine residents' access to health facilities, I utilized Reference USA (www.referenceusa.com) between September and November 2016 to find the geographic locations of facilities that influence health. These include food stores, healthcare facilities, physical recreation centers, and public administration buildings. Fleischhacker, Rodriguez, Evenson, Henley, Gizlice, Soto, & Ramachandran (2012) determined that ReferenceUSA had a nearly perfect sensitivity when tested against in-person built environment assessments. This data was used to determine the access that the average resident has to healthy food, adequate medical facilities, and other built environment characteristics that can influence health.

Finally, the ACS will provide the sociodemographic information that I used to compare counties and their prevalence rates of diabetes. For the purposes of this analysis, I used the ACS variables of race, income, education, and employment status to determine the socioeconomic status of residents living in particular counties in the state of Georgia. I go into further detail about each variable in the next section.

## 5.2 Variables

### *5.2.1 Dependent Variable*

The dependent variable in this analysis is the prevalence of diabetes. This variable is derived from questions on the BRFSS and asked as a dichotomous variable (as in “Have you ever been told by a doctor that you had diabetes?”). It was aggregated to the county level and analyzed through prevalence rates per 100 population. I conducted these analyses to determine whether the built environment has an influence on diabetes prevalence, and if so, whether areas with a higher risk for diabetes actually have a higher diabetes prevalence.

### *5.2.2 Independent Variables*

To conduct these analyses, there are several independent variables that were examined. The demographic and area socioeconomic indicators come from the ACS 2011-2015 5-year estimates. From this data, I constructed a neighborhood disadvantage scale, one originally developed by Robert & Ruel (2006). To develop the neighborhood disadvantage scale, I summed the percentage of households receiving public assistance, the percent of adult unemployment in the area, and the percentage of families with more than $30,000 in annual income (reverse-coded). This scale has shown to be valid in other neighborhood-related research (Robert et al., 2006; Ruel et al., 2010). Higher scores indicate a more disadvantaged area.

The second variable constructed was the dissimilarity index. This variable is a proxy for determining racial residential segregation in counties throughout Georgia. The dissimilarity index shows the proportion of black residents in each county that would have to move to predominately white areas for the population to be fully integrated. The data for this variable comes also from the ACS, and consists of the proportion of black and white residents in the counties where they reside, divided by the overall population of black and white residents in the state of Georgia. The formula is as follows: $\frac{1}{2}\Sigma(b_i/B - w_i/W)$, where $b_i$ equals the black population in a county and $w_i$ equals the white population in the same county, and B and W equal the population of black and white residents in the state of Georgia, respectively. This yields a dissimilarity index score that can be used to show the extent to which black residents in each county live in segregated areas. The third variable consists of the percentage of African-Americans living in each county in Georgia. Finally, the fourth variable derived from the ACS is population density. This variable consists of the total population of a county divided by the square footage of the same.

Most the independent variables come from a built environment scan. These variables were geocoded and mapped to determine whether different facilities exist in counties throughout Georgia. There are several facilities under different categories that influence health in the built environment. These categories include food and consumption, healthcare facilities, physical activity, and public administration.

Supermarkets, grocery stores, community food services, and farmer's markets fall under the positive food environment, as they are the facilities most likely to have fresh fruits and vegetables and other healthy foods at the lowest cost. Bars, convenience stores, fast food restaurants, liquor stores, full-service restaurants, and tobacco shops fall under the negative food environment because they are the facilities likely to serve or sell food, but are least likely to have fresh fruits and vegetables at a low cost. Healthcare facilities are comprised of every conceivable

**Table 5.2. Built Environment Independent Variables**

| **Variable** | Types | NAICS Codes |
|---|---|---|
| Positive Food Environment Variables | Community Food Services, Farmer's Markets, Grocery Stores, Supermarkets | 624210, 445230, 445110 |
| Negative Food Environment Variables | Bars, Convenience Stores, Fast Food Restaurants, Liquor Stores, Sit-Down Restaurants, Tobacco Shops | 722410, 445120, 722513, 447110, 445310, 722511, 453991 |
| Healthcare Facilities | Child and Youth Services, Chiropractors, Dentists, Elderly and Disabled Services, Family Planning Centers, Freestanding Emergency Centers, HMO Medical Centers, Kidney Dialysis Centers, Live-In Disability Facilities, Live-In Rehab Centers, Mental Health Practitioners, Miscellaneous Health Practitioners, Nursing Care, Optometrists, Other Individual and Family Services, Other Outpatient Care Centers, Outpatient Mental Health and Substance Abuse Centers, Physical, Occupational, and Speech Therapists, Physicians, Podiatrists, Retirement Facilities | 624110, 621310, 621210, 624120, 621493, 621491, 621492, 623210, 623220, 621330, 621399, 623110, 621320, 624190, 621498, 621420, 621340, 621112, 621111, 621391 |
| | General Hospitals, Psychiatric and Substance Abuse Hospitals, Specialty Hospitals | 623311, 622110, 622310 |
| Physical Activity | Parks, Sanctuaries, Physical Recreation Facilities | 712190, 713940 |
| Public Administration | Public Health Services, Ambulance Services, Fire Protection, Police Protection | 923120, 621910, 922160, 922120 |

health-related facility available in the North American Industry Classification System (NAICS), including hospitals, specialists, and primary care facilities. Physical activity facilities include publicly owned parks and sanctuaries, along with privately owned locations such as pay-by-month gyms. Finally, public administration consists of public facilities such as public health services, ambulance services (public and private), and fire and police protection stations. Please see Table 5.2 for a full list of all built environment variables and which category they fall in.

## 5.3 Plan of Analysis

### *5.3.1. Small Area Estimation*

As stated above, I used information derived from the BRFSS to provide estimates of the prevalence of diabetes at the county level. The BRFSS, as conducted, is designed to be representative only at the state level and claims that it is no longer reliably accurate at geographic levels smaller than that (Parsons et al., 2008, SAE, n.d.). Thus, a method was needed to reliably predict diabetes prevalence at a smaller geographic level.

Small area estimation has become a popular method for estimating health factor prevalence at smaller than state or national levels. Many surveys do not collect enough health data to be reliable at smaller areas, such as county or census tract levels. Health information, such as dietary habits, physical activity, and obesity levels are found in large surveys, but not so often in smaller ones (Raghunathan et al., 2007). To make estimates for smaller areas with an accurate level of precision, researchers can use indirect estimates that use information from outside sources with similar characteristics (SAE, n.d., Zhang, Zhang, Penman & May, 2011).

Small area estimation is a relatively new method for estimating health variables at small geographic areas. With complex statistical manipulation, it is possible to reliably predict diabetes prevalence at the county level, rather than the state level. This technique has been used to obtain the county-level estimates of diabetes prevalence that I used in these analyses. With these estimates, I could conduct a geospatial analysis to determine the relationship between the prevalence of diabetes and residents' access to resources.

### *5.3.2 Descriptive and Hot-Spot Analysis*

Using data obtained by Reference USA and the ACS, I mapped multiple aspects of the built environment. These included all the health-related facilities mentioned above. The built environment is an important influence on health. Previous researchers have discussed the need for examining health issues at small geographic areas (Diez-Roux, 2007). There are three major strategies in determining built environment effects on health. The first of these strategies is ecologic studies, which in the health field study variations in morbidity and mortality rates. It is also often used to generalize up geographically, to levels well above the neighborhood level (Diez-Roux, 2001). The second strategy are contextual or multilevel studies. These require data sets including individuals nested within areas or neighborhoods (Diez-Roux, 2001). My study used this strategy, but used small areas nested within larger areas, such as states. The third strategy is using a comparison of small numbers within well-defined neighborhoods. As is evident, much work on determining small-area estimates depends on small area data collection.

Hot-spot analyses generate clusters through the Getis-Ord Gi statistic, which determines where features cluster spatially (Getis & Ord, 1992). This is determined by the features of neighboring areas. Getis-Ord Gi produces significant results only when many neighbors also have the same significantly high or low values. Getis and Ord (1992) define their statistic as the following:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{\left[ n \sum_{j=1}^{n} w_{i,j}^2 - \left( \sum_{j=1}^{n} w_{i,j} \right)^2 \right]}{n-1}}}$$

where $x_j$ is the attribute value for feature $j$, $w_{i,j}$ is the spatial weight between feature $i$ and $j$, $n$ is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\bar{X}\right)^2}$$

which produces a z-score ($G^*_i$). Hot-spots are those areas with statistically significant positive z-scores, while cold-spots are the areas with statistically significant negative z-scores (Mitchell 2005). These are mapped and displayed to show where hot-spots exist throughout Georgia.

### *5.3.3 Gaussian-Based Two-Step Floating Catchment Area Method*

The Gaussian-Based Two-Step Floating Catchment Area (GB2SFCA) method examines the reasonable distance for which a facility can expect to service an area (Wang & Luo, 2005). In other words, it provides a ratio of a health facility (such as supermarkets) to the surrounding population (Luo & Wang, 2003a, b). In the first step, catchments (i.e. the surrounding population) are calculated around each supply point (i.e. a supermarket), creating a population-to-provider ratio. The equation for step one is as follows:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \le d_0\}} P_k},$$

where $P_k$ is the population of area $k$, $S_j$ is the number of facilities (such as supermarkets) at location $j$, and $d_{kj}$ is the travel time between $k$ and $j$. In the second step, travel-time catchments are calculated around the population points, and accessibility is measured by summing all the ratio values contained in the area of interest. The equation for step two is below:

$$A_i^{\mathrm{F}} = \sum_{j \in \{d_{ij} \le d_0\}} R_j = \sum_{j \in \{d_{ij} \le d_0\}} \left( \frac{S_j}{\sum_{k \in \{d_{kj} \le d_0\}} P_k} \right),$$

where $A_i^F$ represents accessibility at resident location $i$, $R_j$ is the facility to population ratio at location $j$ that falls within the catchment centered at $i$, while $d_{ij}$ is the travel time between $i$ and $j$ (Wang et al. 2004). These two geospatial density models can be used to determine how health facilities are grouped within the built environment.

There are several steps associated with conducting a GB2SFCA analysis. First, I calculated the population-weighted centroids in each census tract throughout Georgia, stratified by county. Then, I aggregated the census-tract centroids to the county level to give an accurate point where most of the population in that county lives. Next, I calculated the Euclidean distance (as the crow flies) for each county to set catchment boundaries. For urban counties, the catchment area was one mile, while for rural counties, the catchment area was ten miles. This distance differential is used in the 2006 and 2010 USDA Food Atlases and used here (USDA 2010). Next, I calculated the Gaussian function for weight. This helps weight both population and the health-facility-to-population ratio to ensure that both the facility and the population are accurately represented in the results. The Gaussian function for weight is as follows:

$$G(d_{ij}, d_0) = \begin{cases} \frac{e^{-1/2\times(d_{ij}/d_0)^2} - e^{-1/2}}{1-e^{-1/2}} & \text{if } d_{ij} \leq d_0 \\ 0 & \text{if } d_{ij} > d_0 \end{cases}$$

where *d* is the distance of features *i* and *j*, population and health facility, respectively. Finally, I mapped the spatial accessibility of the population of each county to the health facilities in the county, and could derive an accessibility value for positive food outlets, negative food outlets, healthcare facilities, physical activity centers, and public administration facilities in each county throughout Georgia.

#### *5.3.4 Linear Regression Analysis*

The penultimate analysis that I conducted at the county level is an ordinary least squares (OLS) regression analysis. I determined the relationship between the prevalence of diabetes and access to health facilities, stratified by race, income, and geographic density.

A regression equation regresses individual variables while controlling for all other variables within the equation. A generic regression equation is as follows: $\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \ldots + b_kX_k$, where $\hat{Y}$ is the predicted value of the dependent variable, $b_0$ is the intercept where the slope meets the Y axis, and each variable is designated as $b_yX_y$, where $b_y$ is the predicted change in Y for a one-unit increase in $X_y$, controlling for all other variables. I conducted a regression of the prevalence of diabetes at the county level. Please see Figure 5.1 for the regression equation:

$$\hat{Y}_{\text{diabetes prevalence}} = b_0 + b_1X_{\text{neighborhood disadvantage}} + b_2X_{\text{dissimilarity index}} + b_3X_{\text{population density}} + b_4X_{\text{built environment facility}}.$$

**Figure 5.1. Regression Equation for Diabetes Prevalence.**

To use OLS regression, several assumptions must be met. The first assumption states that all scores of a variable should either be dichotomous or quantitative. In this case, all the variables in the analysis already meet this assumption. The second assumption is that the results of the variables should be reasonably normally distributed. To meet this assumption, I examined univariate histograms and scatterplots to assure reasonable normal distribution, and created dummy variables for those that are skewed or kurtostic. The third assumption is that for each pair of variables, the joint distribution should be bivariate normal as well as linear. I conducted a visual examination of the normal distribution to ensure that this is the case. To satisfy the assumption of homoscedasticity, I conducted an analysis of scatterplots of the standardized and predicted residuals of all variables.

The ordinary least squares regressions were run to test all the hypotheses. It examined the associations between the percentage of African-Americans living in a county, the neighborhood disadvantage scale, and urban or rural residence and the percentage of built environment facilities in a county. Finally, to ensure that this model of analysis is the best fit for the data, I used R-squared and ANOVA F-test statistics. The significance threshold for these tests and for all other variable significance tests is at $\alpha \leq 0.05$. Significant $R^2$ and ANOVA results will indicate that the observed $R^2$ is a reliable measure in the population from which the sample was drawn, while $R^2$ itself determines the percentage of variance in the dependent variable that is explained by the overall model. The linear regressions were run using SPSS 21.0.

### *5.3.5 Spatial Regression Analysis*

The final analysis I conducted on this data was a spatial regression analysis. As the entirety of this dissertation focuses on the spatial accessibility of health-related facilities and the distribution of diabetes prevalence rates throughout Georgia, it was important to include a geospatial regression analysis along with the general ordinary least squares regression analysis. The spatial analyses improve on the ordinary least squares regressions by adding a spatial weight to the statistical models. In research involving geospatial distances, in general both types of regressions are run to determine the extent to which location plays a part in the association between the dependent, independent, and control variables.

Tobler's first law of geography states that "all places are related, but nearby places are more related than distant places" (Tobler, 1970). This is otherwise known as spatial autocorrelation. It measures the degree to which near and distant features are related. To conduct a spatial regression analysis, there are several steps to be followed. First, all the assumptions and characteristics of a normal ordinary least squares regression must be met. Next, a spatial weights matrix must be created to assign weights to areas that are nearer to each other. Next, the spatial regression, with the weights matrix applied, can be run.

In this analysis, I ran the ordinary least squares regression first, and then ran the spatial regression. To capture the characteristics of all neighbors of any given county, I used Queen's Contiguity to establish spatial weights (see Figure 5.2). Other types of contiguities capture some, but not all, of the nearest neighbors. The spatial regression was conducted using GeoDa 1.8.14. With this information, I could determine the extent to which spatial characteristics influenced the variables in this study.

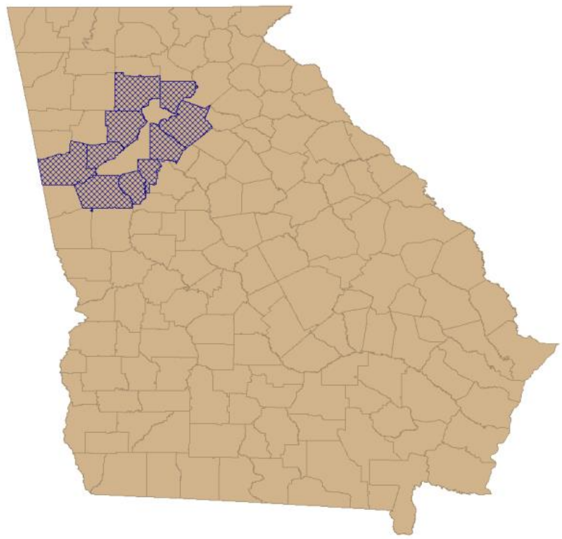


**Figure 5.2 An example of Queen's Contiguity.**

These methods of analysis are useful in determining the relationship between geospatial access to health facilities and the prevalence of diabetes in counties throughout Georgia. Through obtaining data developed through small area estimation and collecting data to conduct geospatial and regression analyses, I determined whether there is a relationship between one's built environment (specifically one's access to health facilities) and the county-wide prevalence for diabetes.

# 6 RESULTS – HOW DOES NEIGHBORHOOD COMPOSITION INFLUENCE THE BUILT ENVIRONMENT?

Georgia is a diverse state, with representation across multiple races, incomes, and other sociodemographic characteristics. With 159 counties, there is a broad range of availability to supermarkets, physical recreation facilities, or other health-promoting facilities. Please see Table 6.1 for a list of characteristics and built environment features of Georgia.

**Table 6.1. A breakdown of Georgia's characteristics (n=159).**

| Variable | Mean/Median/Count | Range |
|---|---|---|
| Dissimilarity Index | 0.31 | 0.02 – 0.95 |
| Neighborhood Disadvantage | 68.27 | 24.6 – 112.2 |
| Population | 9,665,974 | |
| Population Density | 66.30 | 8.5 – 2585.7 |
| Urban Counties | 50 | |
| Rural Counties | 109 | |
| Education (% with HS Diploma) | 76.50 | 58.4 – 93.6 |
| Unemployment Rate | 8.60 | 3.1 – 20.5 |
| Median Household Income | 37,522 | 22,188 – 87,605 |
| % Caucasian | 66.7 | 14.3 – 97.2 |
| % African-American | 28.4 | 0.1 – 85.2 |
| % Diabetes Prevalence | 12.4 | 6.6 – 17.1 |
| # of Grocery Stores | 5 | 0 – 261 |
| # of Supermarkets | 3 | 0 – 126 |
| # of Bars | 0 | 0 – 192 |
| # of Convenience Stores | 20 | 1 – 525 |
| # of Fast Food Restaurants | 12 | 0 – 841 |
| # of Full-Service Restaurants | 20 | 0 – 2,084 |
| # of Liquor Stores | 3 | 0 – 180 |
| # of Healthcare Facilities | 46 | 1 – 5,277 |
| # of Physical Activity Facilities | 5 | 0 – 494 |
| # of Public Administration | 13 | 1 – 175 |
| # of Tobacco Stores | 0 | 0 – 68 |
| # of Positive Food Outlets | 9 | 0 – 416 |
| # of Negative Food Outlets | 55 | 2 – 3,890 |
| **Total n = 159** | | |

The high and low range values for each variable were also calculated. For the dissimilarity index, Clinch County scored lowest with a dissimilarity index score of 0.02, while Cobb County scored the highest with a score of 0.95. For neighborhood disadvantage, Forsyth County scored the lowest with a neighborhood disadvantage score of 24.60, while Clay County scored the highest at 112.20. Fulton County has the highest population at 920,581, while Taliaferro County has the lowest population at 1,717. Clinch County is the least population dense county with 8.50 people per square mile, while DeKalb County is the densest with 2,585.70 people per square mile. For education, Taliaferro County ranked lowest with a high school graduation rate of 58.4%, while Fayette County ranked highest with a graduation rate of 93.6%. The unemployment rate was lowest in Wheeler County (3.10%), while Clay County had an unemployment rate of 20.50%. Taliaferro County has the lowest median income for Georgia, with a median income of $22,188, while Forsyth County has the highest at $87,605. Hancock County has the lowest percentage of Caucasians, with only 14.3% of the population identifying as white, while Towns County has the highest percentage at 97.2%. Fannin County has the lowest percentage of African-Americans (0.1%), while Hancock has the highest at 85.2%. Finally, Chattahoochee County's population has the lowest rates of diabetes at 6.6%, while McDuffie County has the highest rates of diabetes at 17.10%.

For the built environment characteristics, there was also quite a bit of variability. Five counties (Chattahoochee, Glascock, Irwin, Quitman, and Taliaferro) claimed no grocery stores at all, while Fulton County had the most with 261. The same five counties had the lowest grocery store county per 1,000 population, while Baker County had the highest concentration at 0.87 grocery stores per 1,000 residents. Twenty-three counties had no supermarket at all (interestingly, including Baker County, but also including four of the five counties above with no grocery stores either), while again Fulton County had the most at 126. Schley County had the highest concentration at 0.40 supermarkets per 1,000 population. Eighty-seven counties have no bars, while Fulton County has the most at 192. Clarke County has the dubious distinction of having the most bars per 1,000 population, with a concentration of 0.32. Ten counties have no fast food restaurants at all. Fulton County has the most at 841, while Bibb County has the highest concentration of 1.11 fast food restaurants per 1,000 population. Baker and Echols Counties have no full-service restaurants, while Fulton has both the highest number and concentration of restaurants, at 2,084 and 2.26 per 1,000 population respectively. Thirty-two counties have no liquor stores, while Fulton County has the most at 180, and Seminole County has the highest concentration at 0.46 liquor stores per 1,000 population. Finally, for tobacco stores (excluding convenience stores), eighty-four counties have no tobacco stores at all, while Fulton County has the most at 68 and Fannin County has the highest concentration at 0.17 tobacco stores per 1,000 population.

The five major variables (positive food, negative food, healthcare facilities, physical activity, and public administration) also show a good amount of variation. Four counties (Chattahoochee, Glascock, Quitman, and Taliaferro) have no positive food outlets at all. Fulton County, of course, has the most, with 416 total positive food facilities, while Turner County had the highest concentration with 1.01 positive food facilities per 1,000 population. Every county has some measure of negative food outlets, but Taliaferro County had the least with two, while Chattahoochee County had lowest concentration with 0.53 per 1,000 population. Fulton County had the highest number of negative food outlets with 3,890, and McIntosh County had the highest concentration with 5.03 negative food outlets per 1,000 population. Quitman County had the fewest healthcare facilities, with only one in the entire county, while Chattahoochee County had the lowest concentration, with 0.36 healthcare facilities per 1,000 population. Fulton County had both the highest number and highest concentration of healthcare facilities, with 5,277 and 5.73 per 1,000 population, respectively. For physical activity facilities, twenty counties have no recreation or physical activity facilities, while Fulton County has the most with 494. Wilkes County has the highest concentration with 0.85 facilities per 1,000 population. Finally, for public administration, Webster County had the least number of facilities, only one for the county, while Gwinnett County had the lowest concentration, with 0.05 facilities per 1,000 population. Fulton County had the most, with 175 facilities, while Glascock County had the highest concentration, with 2.27 facilities per 1,000 population.

For this first results chapter, I will display the results for the first question and the three hypotheses. As a reminder, the first question asks, "How does neighborhood composition influence the built environment?" The three hypotheses are as follows. First, the built environment will vary based on the racial makeup of the residents who live there. Second, the built environment will vary based on the income makeup of the residents who live there. Finally, the built environment will vary based on the geographic density of the areas where people live. To display these results, I will first examine the descriptive and hot-spot analyses. Next, I will examine the GB2SFCA results through mapping. Finally, I will investigate the linear and the geospatial linear regression analyses to determine the extent to which the independent variables influence the dependent variables. These analyses will answer the overall question along with the three hypotheses.

## 6.1 Hypothesis 1A. The Built Environment Will Decline as African-American Presence in a County Increases.

### *6.1.1 Descriptive and Hot-Spot Analyses*

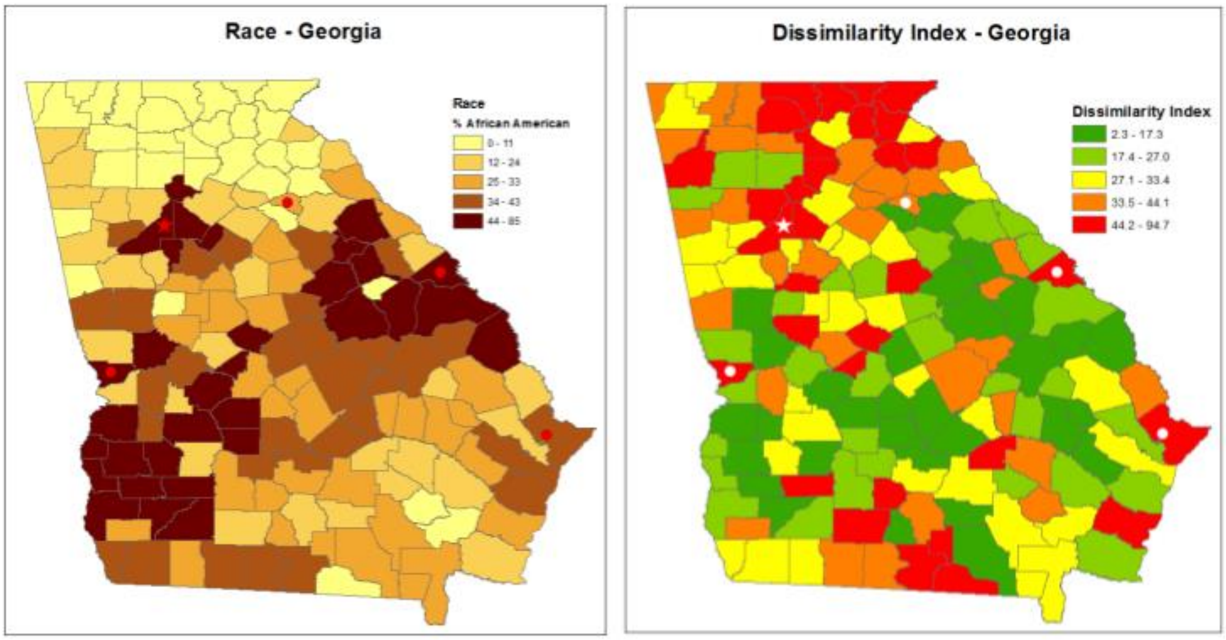



**Figure 6.1. Race and Dissimilarity Index Scores per County.**

The first two maps (Figure 6.1) show the racial makeup and the dissimilarity index scores for each county in Georgia. As shown, there is a fair amount of segregation even at the county level. The northern part of Georgia is predominately Caucasian, while central and southwest counties in Georgia are predominately African-American. What is interesting is that in predominately Caucasian areas, the dissimilarity index is very high, while in majority African-American areas, the percentage of African-Americans who would have to move to predominately Caucasian areas to achieve racial evenness is much lower.

In Figure 6.2, the map of racial distribution in Georgia is overlaid with the locations of each type of built environment variable. The first map shows the distributions of both race and positive food outlets (supermarkets and grocery stores) in Georgia. There are a total of 3,407 positive food outlets in Georgia. The positive food outlets are concentrated predominately in urban areas, mostly around Atlanta and the metro area. The southern area of Georgia has very few positive food outlets, and a few counties have none.

The second map shows racial distribution and negative food outlets (bars, convenience stores, fast food restaurants, liquor stores, full-service restaurants, and tobacco shops). In Georgia, there are 26,209 negative food outlets. Again, these are concentrated around Atlanta and surrounding areas, but there are also ‘lines’ of negative food outlets that follow the major freeways throughout the state. There are also many more negative food outlets in the northern part of the state compared to the southern half.

The third map displays the healthcare facilities throughout the state. This is perhaps one of the most distinctly concentrated variables, as most of the 31,560 healthcare facilities are located in Atlanta or the metro Atlanta area. The areas in the southern part of the state have a more even distribution of healthcare facilities, but also much fewer. Each green dot represents one healthcare facility. There are twenty-four different types of healthcare facilities included in

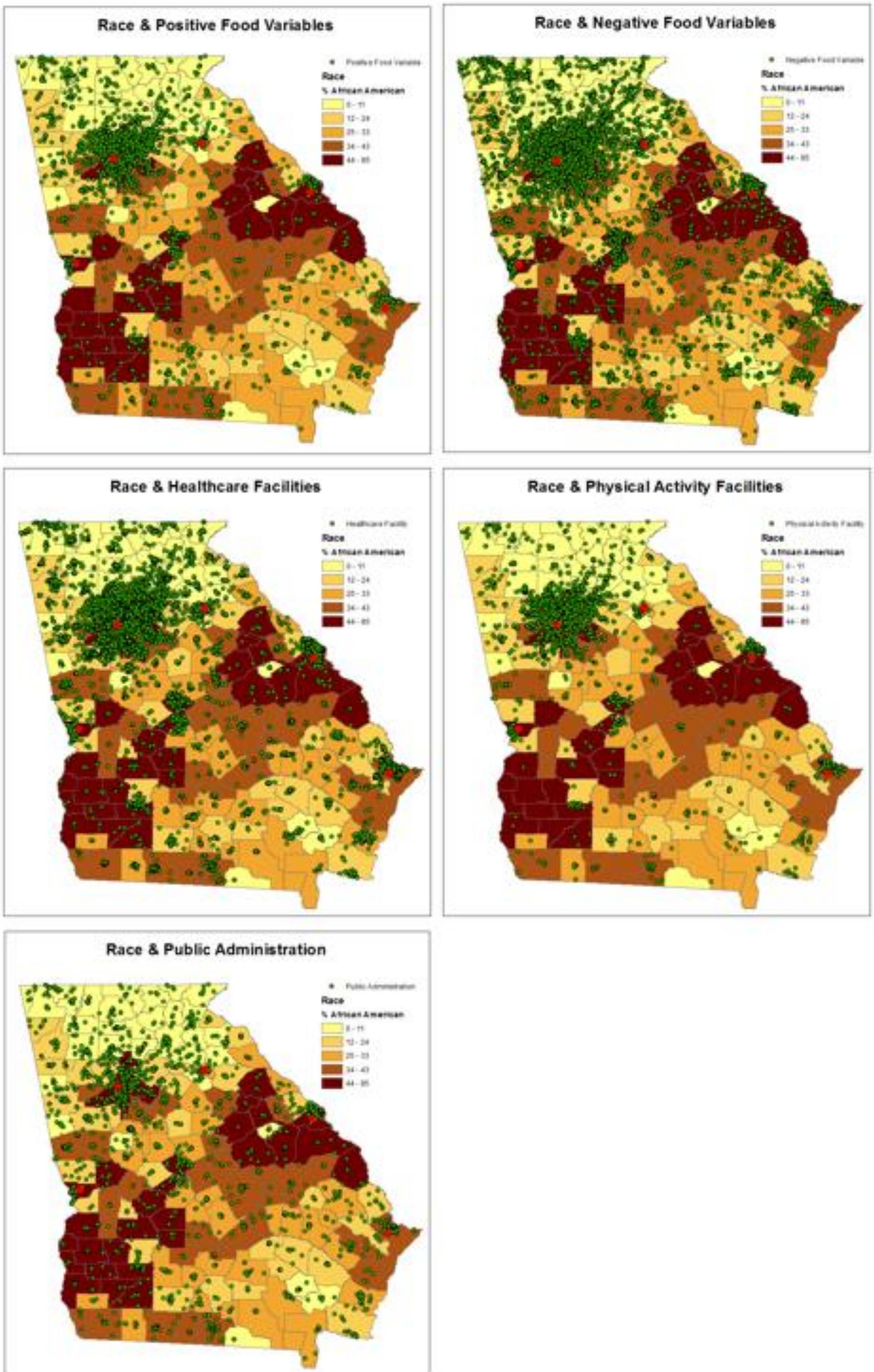



**Figure 6.2. Racial Distribution and Measures of the Built Environment.**

this analysis. So, while a county may appear to be well-represented with healthcare facilities, it is possible that these facilities are very specific (such as kidney dialysis centers).

The fourth map shows the racial and physical activity centers distribution throughout Georgia. Physical activity variables include parks, sanctuaries, and gyms. There are 2,646 facilities in Georgia. They are located predominately in the Atlanta area, and there are quite a few counties, mostly in the south and southwestern parts of the state, that have no accessible physical activity centers at all. It is interesting to note that these same counties are the ones with the highest percentage of African-Americans as well.

The final map is the distribution of public administration facilities throughout the state. These are by far the most equitably distributed, which as predominately public facilities, is appropriate. Public administration facilities include public health services, ambulance services, fire protection, and police protection. There are a total of 2,749 public administration facilities throughout Georgia. Public administration facilities, in this analysis, can serve as an informal control display to show what a distribution of facilities would look like if they were distributed in a fairly equitable fashion.

The next map (Figure 6.3) show the results of the analyses. These maps are the results of the hot-spot analyses conducted on these data. The blue areas constitute areas of 'cold spots' or areas where the variables score lowest. For race, it shows that areas with the lowest percentages of African-Americans, such as north Georgia, are the designated cold spots. The areas in light yellow are areas of average-scoring counties. Sixty-five percent of counties will, in general, fit into this section. Finally, on the other end of the spectrum are the 'hot-spots.' These

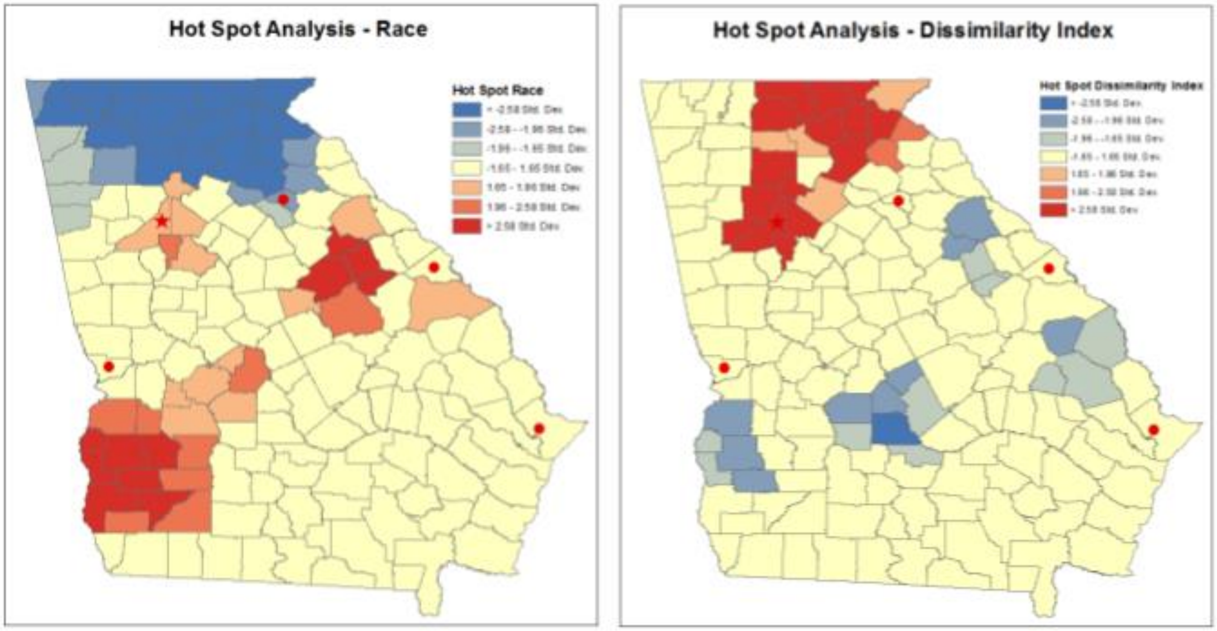



**Figure 6.3. Hot-Spot Analysis of Race and Dissimilarity Index.**

are areas where the variable scores the highest. The red areas range from one standard deviation about the norm to more than two standard deviations above the norm.

The next maps (Figure 6.4) show the results of the hot-spot analyses overlaid by each built environment outlet. For the rest of the spatial descriptive results, I will point out the interesting or unusual features. Except for public administration, it is evident that there are more positive and negative built environment outlets in areas that are predominately Caucasian and in the northern half of Georgia. Areas of high-clustering African-American population, except for DeKalb and Clayton counties, have distinctly fewer facilities overall.

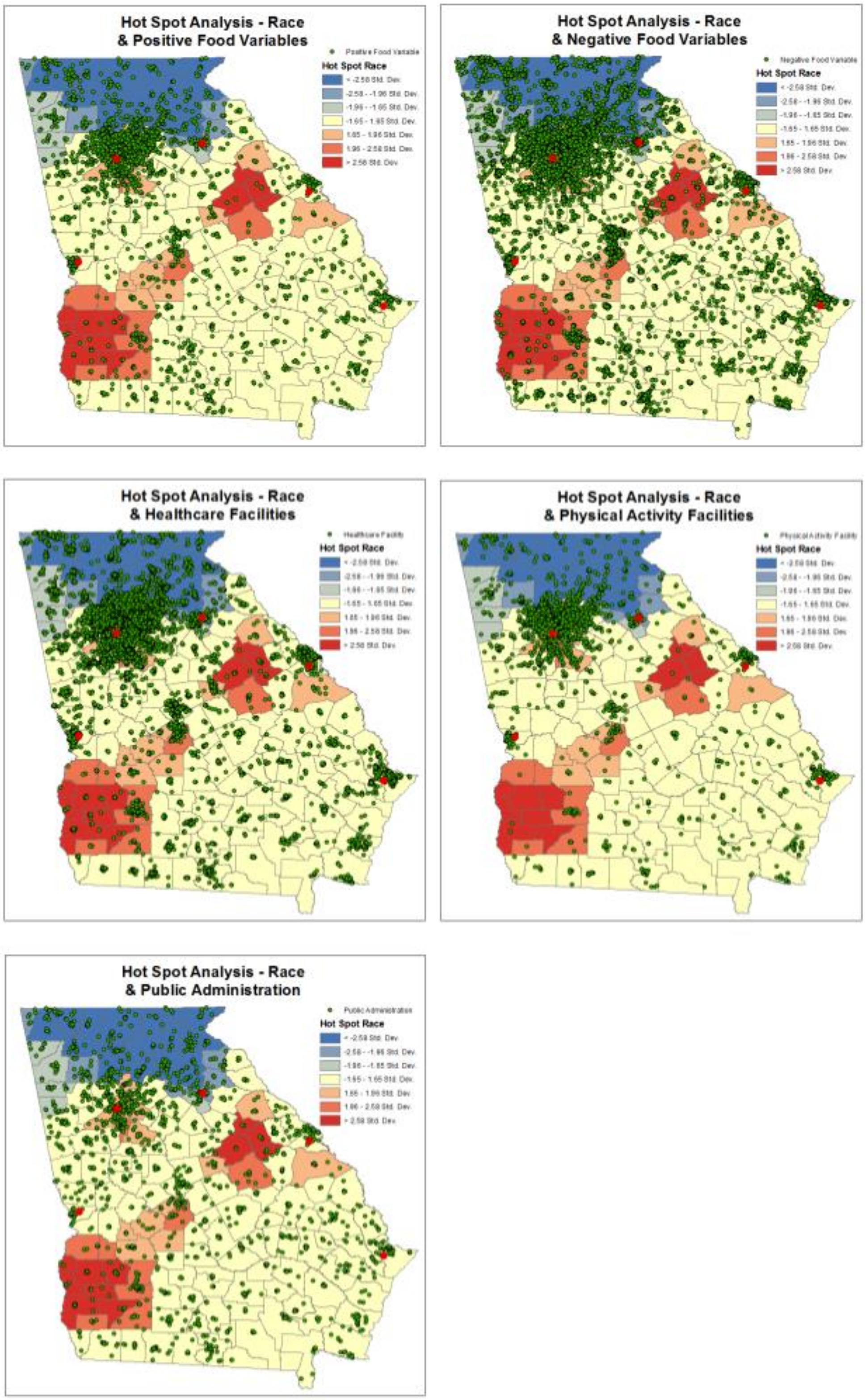



**Figure 6.4. Hot-Spot Analysis of Race and Measures of the Built Environment**.

### *6.1.2 GB2SFCA Method Results*

The Gaussian-Based Two-Step Floating Catchment Area method was used to calculate accessibility of the built environment outlets to the population centers of each county. As stated earlier, the catchment areas calculated for each county varied by its population density status. Figure 6.5 shows which counties are urban and which are rural in Georgia. Urban counties have a catchment area of one mile from the population center to the built environment outlets, while rural areas have a catchment area of ten miles. These distances come from the USDA Food Atlas, and for consistency, are replicated here (USDA, 2010).

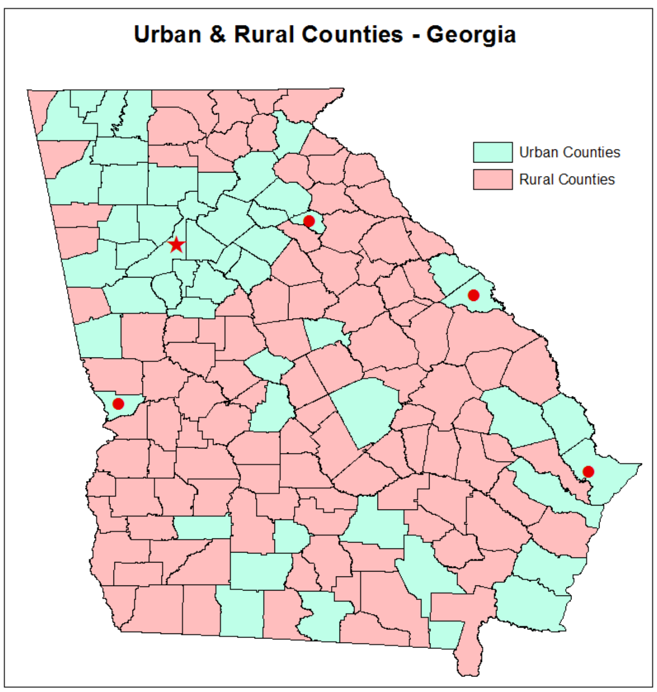



**Figure 6.5. Urban and Rural Counties in Georgia.**

Figure 6.6 shows the overall accessibility for positive food outlets, negative food outlets, healthcare facilities, physical activity facilities, and public administration in each county throughout Georgia. In these maps, the greatest accessibility is associated with the darkest green color, and becomes lighter as accessibility wanes. The counties in white have no accessibility to the relevant built environment outlet. For example, in the first and fourth maps of positive built environment outlets and physical activity facilities, there are multiple counties that have no accessibility to their respective variables. This means that for urban counties, there is not a supermarket, grocery store, or physical activity facility within one mile of the population center. For rural counties, there are no facilities within ten miles of the population center. These are areas of very low accessibility to these variables. These are also the two built environment outlets with the least amount of facilities. The other three built environment outlets, negative food outlets, healthcare facilities, and public administration, are accessible to most counties in Georgia.

The second set of maps (Figure 6.7) show the relationship between the racial makeup of the county and the accessibility to the built environment features around it. In this set, the darker the county, the higher accessibility to each built environment facility type. However, in later accessibility maps, accessibility will be shown as dots upon the sociodemographic variable of interest. Larger dots are counties with higher accessibility, while areas with small or no dots at all have lower or no accessibility to the specific built environment feature. Interestingly, there doesn't seem to be a solid correlation between the racial makeup of a county and its built environment accessibility for any variable, with perhaps the exception of healthcare facilities and physical activity. In the areas of highest African-American population, healthcare facility accessibility is lowest, except for the counties around Augusta. Physical activity facilities have a tendency toward higher accessibility in predominately African-American areas. While the visual examination does not show clear correlations, the linear regressions below are

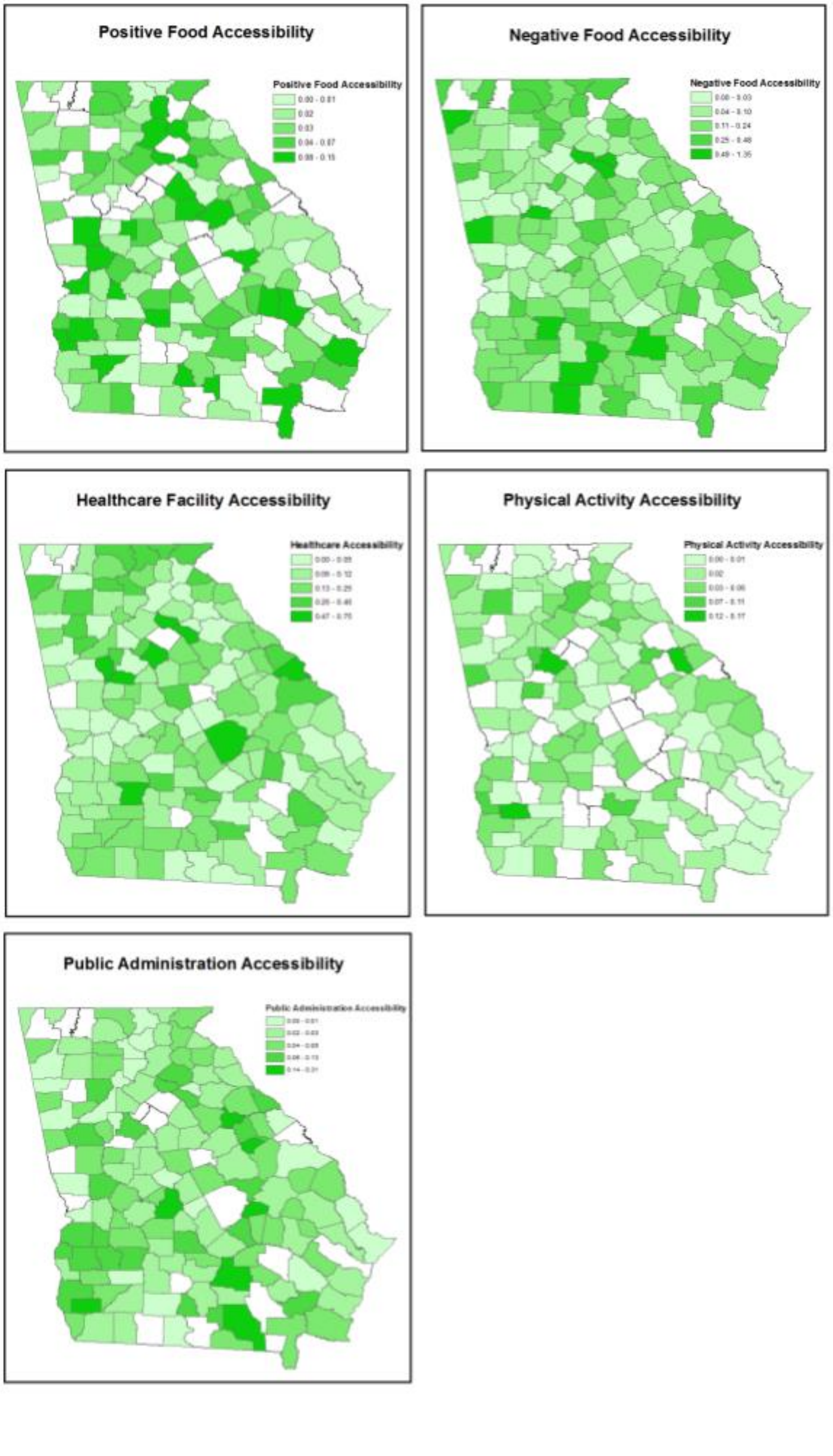



**Figure 6.6. Built Environment Accessibility.**

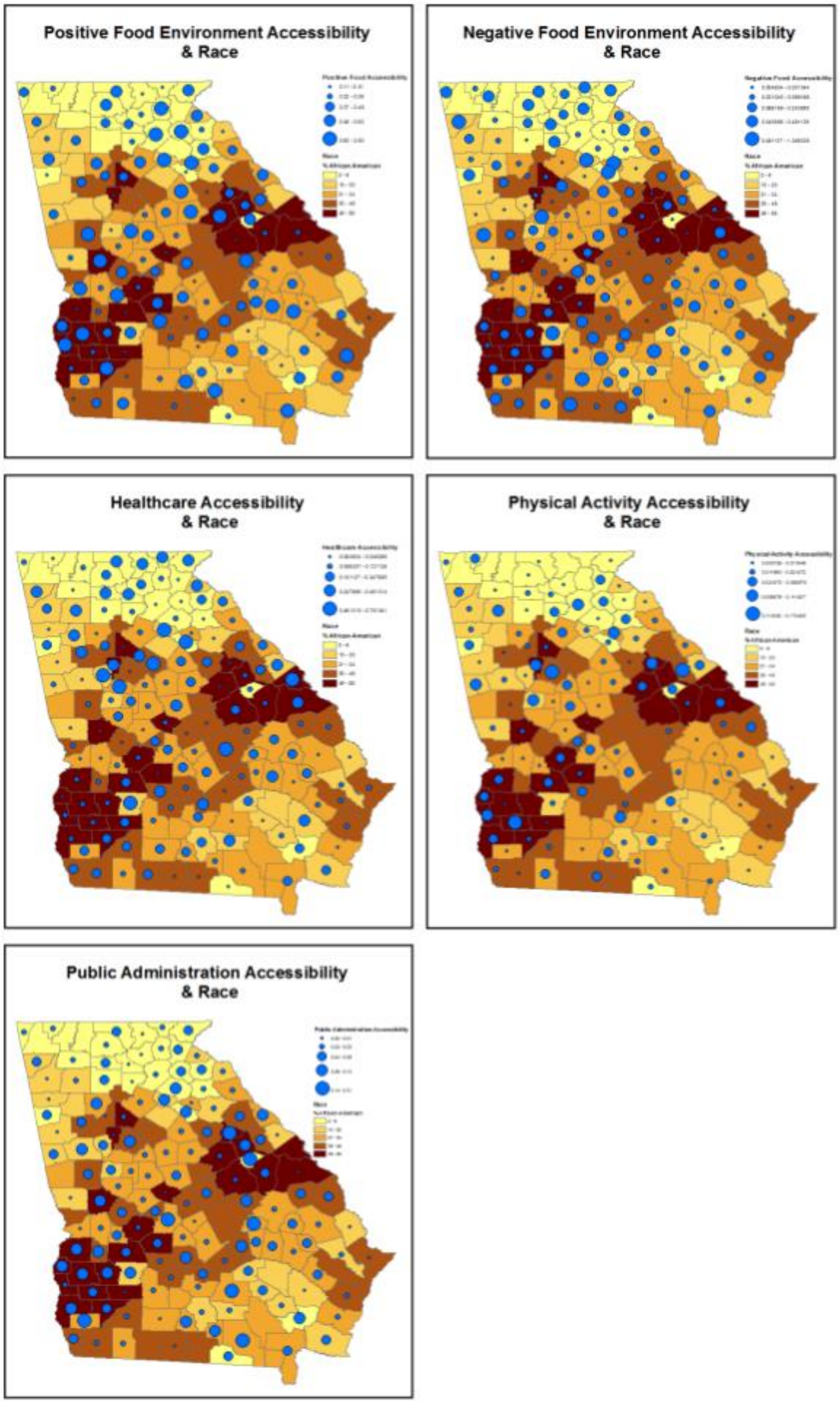



**Figure 6.7. Built Environment Accessibility and Race.**

much clearer on the relationship between the racial makeup of the residents of each county and the built environment facilities to which they have access.

### *6.1.3 Linear Regression Results*

The linear regression results are shown in Table 6.2. These regressions address the hypotheses throughout question one, but will be described in each hypothesis's section. The regressions for this section examine the relationship between the five built environment outlets and the independent variable of race. The ANOVA F-test is significant for all five variables, indicating that the model is a good fit for the data. The adjusted r-squared for the entire model ranges from 0.234 (public administration) to 0.543 (positive food environment). This shows that the dependent variable regressed against the independent variables explain between 23.4 and 54.3 percent of the variation between the two. For four of the five dependent variables, race was significantly positively associated with the availability of built environment outlets. The lone insignificant association was between the percentage of African-Americans in a county and the positive food environment. For negative food environment, for every one percentage increase in African-American population, negative food environment outlets increased by 0.027 percentage points. For healthcare facilities, for every one percentage increase of African-American population in a county, healthcare facilities increased by 0.031 percentage points. For physical activity, for every one percentage increase in African-American population, physical activity facilities increase by 0.029 percentage points. Finally, for public administration, every one percentage point increase in African-American population is associated with a 0.008 percentage point increase in public administration facilities. These increases are significant and controlled by the variables of neighborhood disadvantage scale and urban or rural residence.

**Table 6.2. Linear Regression of Socioeconomic Variables on the Built Environment.**

| Independent Variable | Dependent Variable (%) | | | | |
|---|---|---|---|---|---|
| | Positive Food Environment | Negative Food Environment | Healthcare Facilities | Physical Activity | Public Administration |
| African American (%) | 0.002 | **0.027*** | **0.031*** | **0.029*** | **0.008*** |
| | [0.074] | [0.318] | [0.328] | [0.287] | [0.226] |
| | (0.002) | (0.007) | (0.008) | (0.009) | (0.003) |
| Neighborhood Disadvantage Scale | -0.001 | **-0.034*** | **-0.041*** | **-0.045*** | **-0.009*** |
| | [-0.047] | [-0.353] | [-0.376] | [-0.386] | [-0.220] |
| | (0.003) | (0.009) | (0.011) | (0.012) | (0.004) |
| Urban or Rural Residence | **-0.653*** | **-1.034*** | **-1.056*** | **-0.931*** | **-0.611*** |
| | [-0.725] | [-0.317] | [-0.283] | [-0.234] | [-0.456] |
| | (0.078) | (0.265) | (0.305) | (0.335) | (0.105) |
| | | | | | |
| Intercept | 1.551 | 3.902 | 4.297 | 4.410 | 2.023 |
| | (0.187) | (0.490) | (0.565) | (0.619) | (0.195) |
| R-Squared | 0.543 | 0.288 | 0.274 | 0.234 | 0.330 |
| Adjusted R-Squared | 0.524 | 0.274 | 0.260 | 0.220 | 0.317 |
| ANOVA F-Test | **27.742*** | **20.888*** | **19.529*** | **15.827*** | **25.485*** |

Note: Unstandardized coefficients (b) are listed first; standardized coefficients (β) appear in brackets; standard error ($SE_b$) appear in parentheses
* $p \leq 0.05$

### *6.1.4 Spatial Regression Results*

Spatial linear regression, while similar to the linear regression above, adds a spatial weight to the equation, thus allowing me to determine whether the relationship between the variables is spatially-based or independent of location. This weight is determined by the results of the neighbors of the county in question. Figure 6.8 below shows the distribution of the number of neighbors of counties in Georgia. On average, most counties in Georgia have between four and eight neighbors.

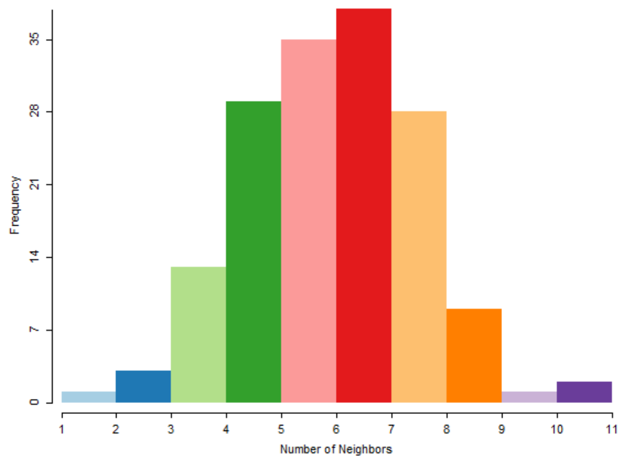



**Figure 6.8. Histogram of County Neighbors in Georgia.**

The results of the spatial regression are in Table 6.3. In this case, the likelihood ratio test serves as the goodness of fit of the model to the data. A significant result indicates that the model is indeed a good fit for the data in a spatial model. Insignificant results indicate that something other than the variables in the equation, along with the spatial weight, are likely to explain the association between the dependent variable and the independent variables. In other words, spatial location would not significantly explain the association between the variables. The results can still be considered significant, but not directly tied to spatial location. For these regressions, the likelihood ratio test is significant in all but the association between public administration and race. For the significant results, this indicates that space has a significant association with race and the built environment outlets. This is corroborated by the r-square values. In the spatial regression, the r-square values range from 0.295 (physical activity facilities) to 0.373 (positive food environment outlets). Thirty-seven percent of the variation between race and positive food environment outlets, 33 percent of the variation between race and negative food environment outlets, 33.6 percent of the variation between race and healthcare facilities, 29.5 percent of the

**Table 6.3. Spatial Regression of the Association between Socioeconomic Factors and the Built Environment**

| Independent Variable | Dependent Variable (%) | | | | |
|---|---|---|---|---|---|
| | Positive Food Environment | Negative Food Environment | Healthcare Facilities | Physical Activity | Public Administration |
| African American (%) | **0.018*** | **0.022*** | **0.024*** | **0.023*** | **0.007*** |
| | [2.921] | [3.075] | [3.027] | [2.586] | [2.607] |
| | (0.006) | (0.007) | (0.008) | (0.008) | (0.003) |
| Neighborhood Disadvantage Scale | -0.014 | **-0.022*** | **-0.025*** | **-0.029*** | **-0.007*** |
| | [-1.750] | [-2.350] | [-2.371] | [-2.506] | [-1.971] |
| | (0.008) | (0.009) | (0.011) | (0.012) | (0.004) |
| Urban or Rural Residence | **-0.782*** | **-0.908*** | **-0.882*** | **-0.746*** | **-0.600*** |
| | [-3.510] | [-3.571] | [-3.051] | [-2.346] | [-5.754] |
| | (0.223) | (0.254) | (0.289) | (0.318) | (0.104) |
| | | | | | |
| Intercept | 2.123 | 2.841 | 2.899 | 2.991 | 1.897 |
| | (0.447) | (0.517) | (0.579) | (0.633) | (0.239) |
| R-Squared | 0.373 | 0.330 | 0.336 | 0.295 | 0.333 |
| Likelihood Ratio Test | **15.848*** | **7.245*** | **10.539*** | **9.729*** | 0.403 |

Note: Unstandardized coefficients (b) are listed first; z-scores appear in brackets; standard error ($SE_b$) appear in parentheses.
* $p \leq 0.05$

variation between race and physical activity facilities, and 33.3 percent of the variation between race and public administration facilities is explained by the model.

All five built environment dependent variables are significantly positively associated with the percentage of African-Americans living in each county in these spatial models. For every one percentage point increase in African-American population, the positive food environment increases by 0.018 percentage points, the negative food environment increases by 0.022 percentage points, healthcare facilities increase by 0.024 percentage points, physical activity increases by 0.023 percentage points, and public administration increases by 0.007 percentage points, controlling for all other variables.

## 6.2 Hypothesis 1B. The Built Environment Will Improve as the Neighborhood Disadvantage Scale Decreases at the County Level.

### *6.2.1 Descriptive and Hot-Spot Analyses*

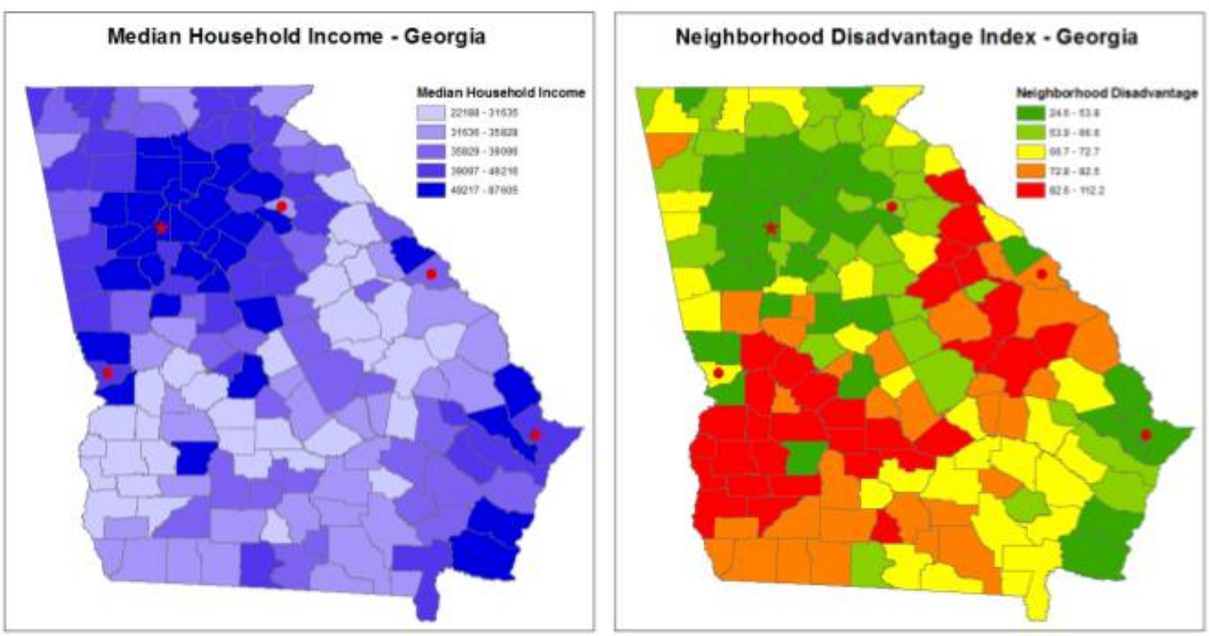



**Figure 6.9. Median Household Income and Neighborhood Disadvantage Index in Georgia.**

For the second hypothesis, I tested the extent to which the built environment varied based on the income distribution of the residents who live in each county. The spatial descriptive analysis is shown in Figure 6.9. In the first map, median household income is distributed in quintiles throughout Georgia. The north central part of Georgia, including Atlanta, has the highest levels of income, while the southwest part of Georgia has the lowest levels. The second map shows the quintile distribution of the neighborhood disadvantage index. The green areas are areas of highest advantage, while the orange and red areas are areas of highest disadvantage. This map corresponds strongly with the blue income map, which is unsurprising.

In Figure 6.10, I examined the distribution of income to the five built environment outlets. For positive food outlets, the visual distribution is strongly in favor of wealthier areas. In areas of higher income, there are more supermarkets and grocery stores. In lower-income counties, the distribution of positive food outlets is much sparser. Negative food outlets follow the same distribution as positive food outlets. There are many more negative food environment outlets in areas of higher income than in lower areas. However, because there are nearly eight times as many negative food outlets than positive in Georgia, there are also a lot more negative food facilities available in lower-income areas than positive. Healthcare facilities also follow the same pattern, where there are more healthcare facilities available in higher income areas than in lower-income counties, except for Richmond County, where the city of Augusta lies. This city has a large teaching hospital and additional supporting healthcare facilities, which skews the generally lower income area toward having more access to healthcare facilities. Physical activity facilities are perhaps the most dramatically disparate regarding income. According to map four above, there are very few physical activity facilities in areas of the lightest blue, or the lowest income areas. The clear majority of physical

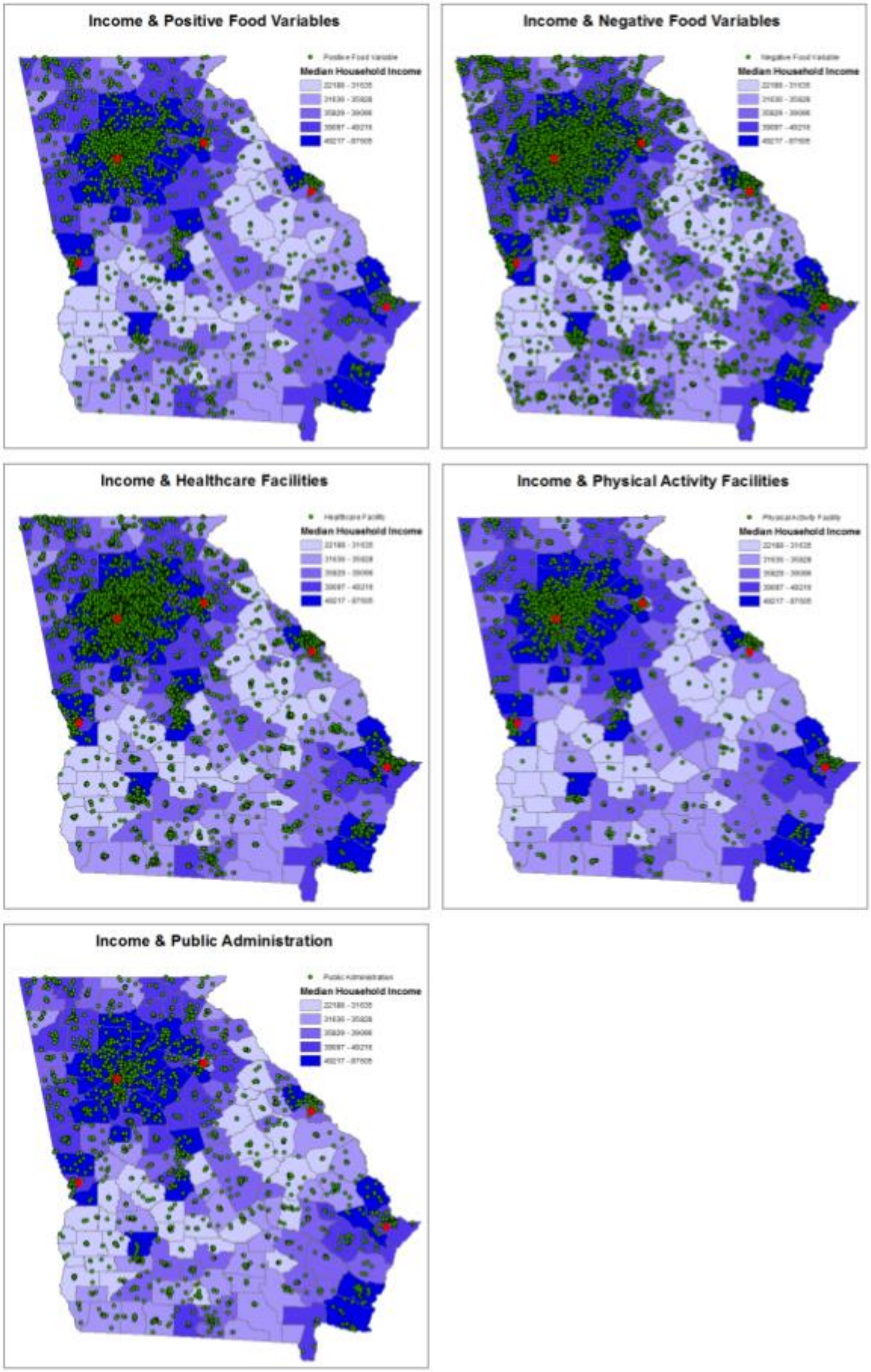



**Figure 6.10. Median Household Income and Measures of the Built Environment.**

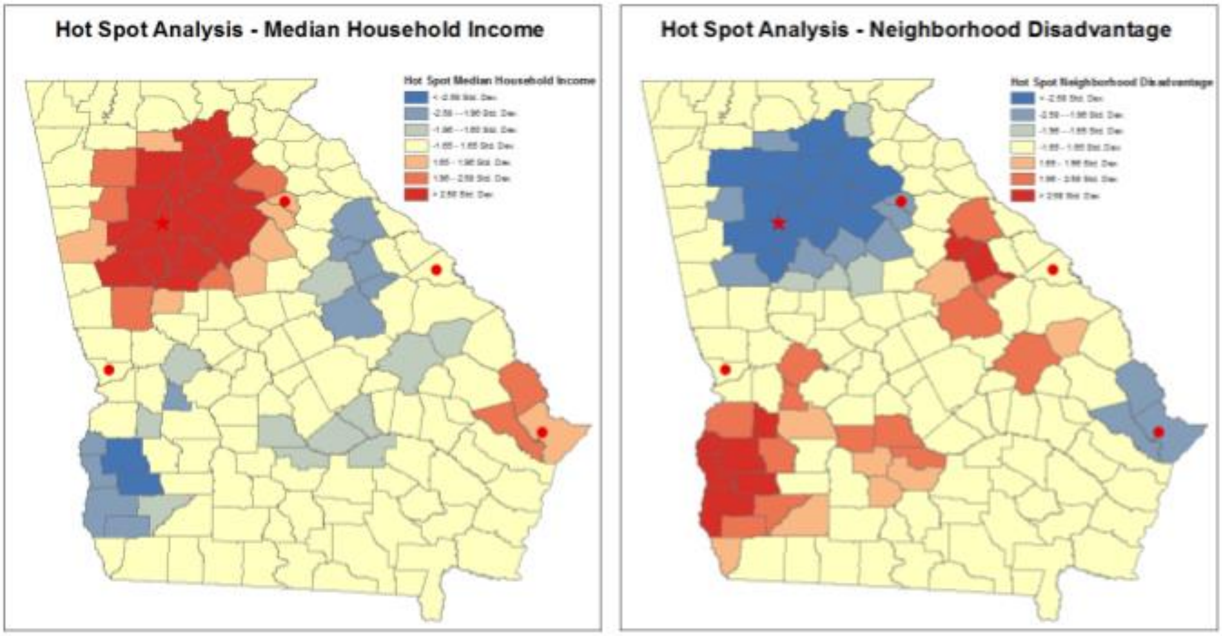



**Figure 6.11. Hot-Spot Analysis of Median Household Income and Neighborhood Disadvantage.**

activity facilities are in areas of higher income. Physical activity facilities include private gyms as well as YMCAs and publicly owned parks, so it is interesting that there would be so few in lower income areas. Finally, public administration facilities are evenly distributed in each county, regardless of income levels.

The maps in Figure 6.11 show the hot-spot analyses for median household income and neighborhood disadvantage. The areas of highest median income are the same as the areas of lowest disadvantage, and surround the cities of Atlanta and Savannah. The areas of lowest income and highest disadvantage are most strongly in the southwest, but trail northeast in a belt through the mid-southern section of Georgia.

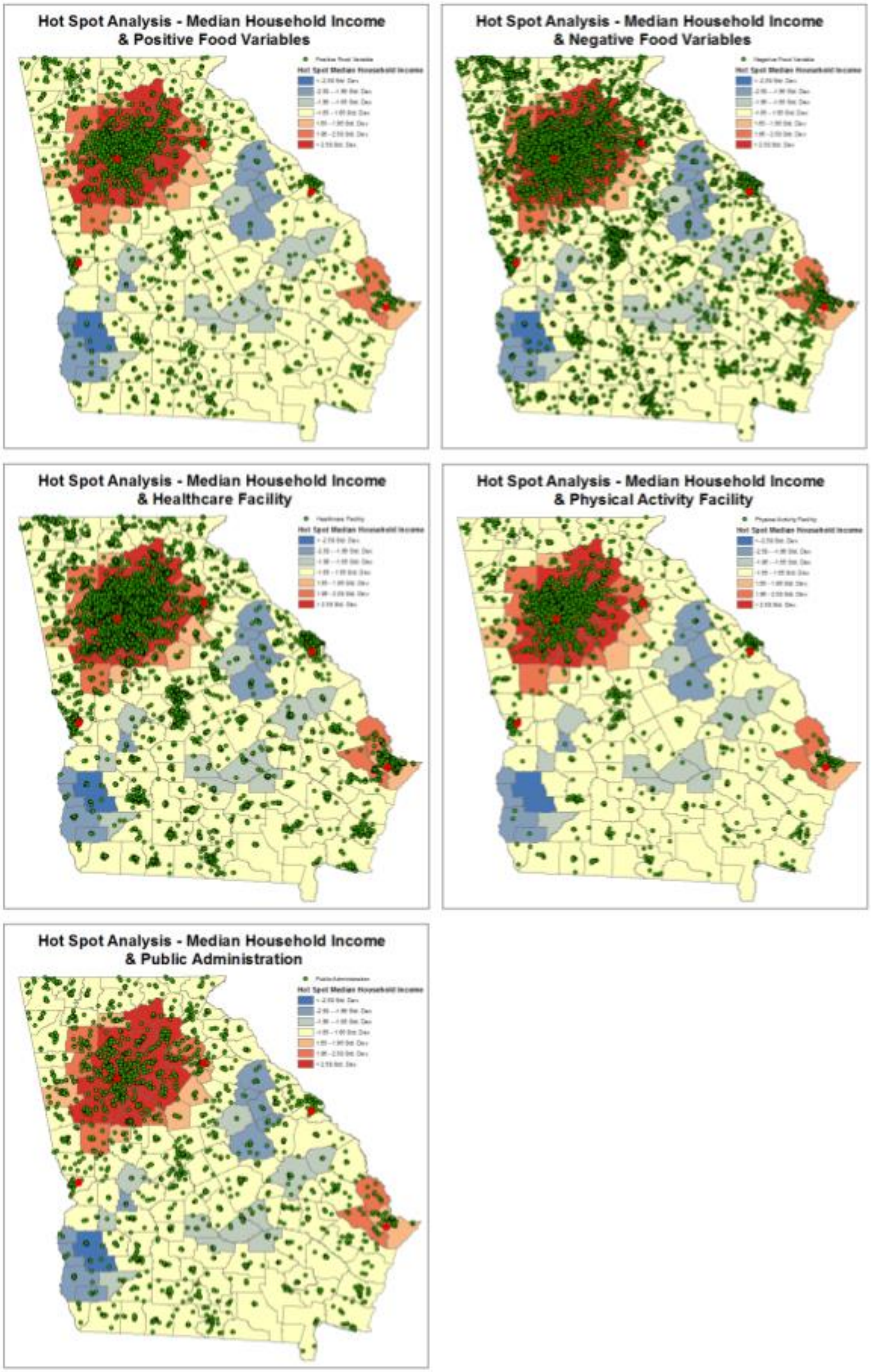



**Figure 6.12. Hot-Spot Analysis of Median Household Income and Measures of the Built Environment.**

The hot-spot analyses for median household income and built environment variables are shown in Figure 6.12. In these maps, it is apparent that as the hot-spot areas of highest median income move out from the centers of Atlanta and Savannah, the number of available positive food outlets, negative food outlets, and healthcare facilities decline. Again, physical activity facilities appear to be the starkest, as they are readily available in areas of highest income, but are very rare to nonexistent in low-income counties. Finally, the hot-spot distribution of income and public administration shows an even distribution.

### *6.2.2 GB2SFCA Method Results*

The maps in Figure 6.13 show the results of the GB2SFCA method results of facility availability, which overlay the income distribution by county of Georgia. As a reminder, these maps show the availability of facilities, not how many facilities are located in a county. The counties with the largest yellow circles show the highest availability of a facility within one mile of the population center in urban counties and within ten miles of the population center in rural counties. Areas with no circle at all do not have that facility available at all within their catchment area. As positive food outlets and physical activity facilities are the least common built environment outlets in Georgia, it is in these maps that there will be counties with no availability results at all.

The results of the GB2SFCA method are interesting. Availability of each built environment outlet may be greater in areas of higher income, but accessibility does not seem to be particularly associated with income. The only variable that seems to have a distinct relationship between accessibility and median income is healthcare facilities. Accessibility is far lower in areas of lower income than in areas of higher income. Besides healthcare facilities, all

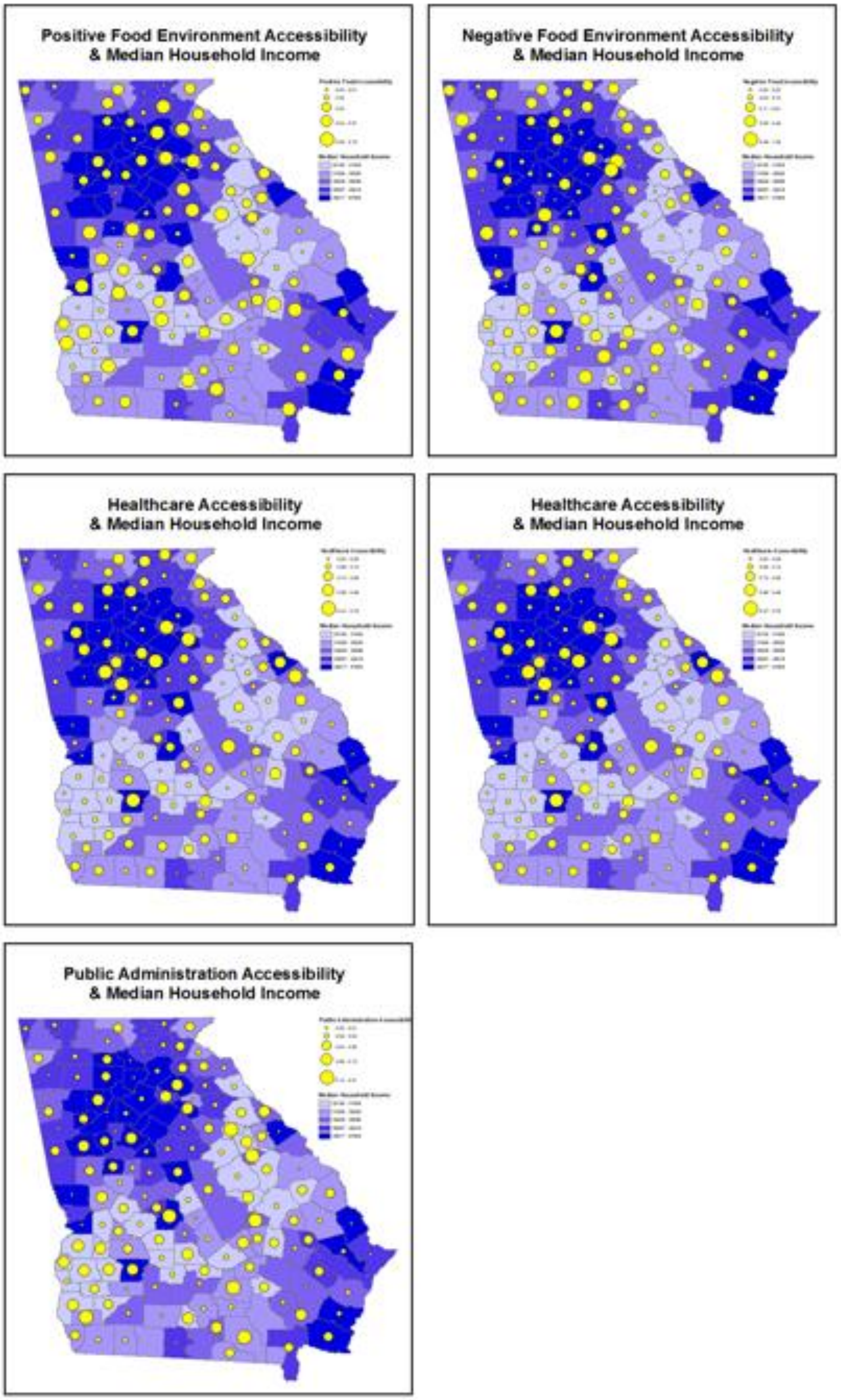



**Figure 6.13. Built Environment Accessibility and Median Household Income.**

other variables are visually as likely to be accessible in lower income areas as in higher income areas.

### *6.2.3 Linear Regression Results*

The linear regression results for the association between the neighborhood disadvantage scale and the built environment are in Table 6.2. In these regressions, the percentage of African-Americans living in a county, along with urban or rural residence with the previous regression serve as controls. The ANOVA F-test and the r-squared results are the same as for hypothesis one, as all regressions were conducted within the same models.

For these regression results, the neighborhood disadvantage scale is the main variable of interest. The only insignificant association in this model is between the neighborhood disadvantage scale and the positive food environment. There is no significant association between the two. For the negative food environment, every one-point increase in the neighborhood disadvantage scale is associated with a 0.034 percentage point decrease in the negative food environment. For every one-point increase in neighborhood disadvantage scale, healthcare facilities decrease by 0.041 percentage points, controlling for all other variables. Every one-point increase in neighborhood disadvantage scale is associated with a 0.045 percentage point decrease in physical activity facilities, on average, controlling for all other variables. Finally, for every one-point increase in the neighborhood disadvantage scale, public administration facilities decrease by 0.611 percentage points.

### *6.2.4 Spatial Regression Results*

The results of the spatial regression analysis are shown in Table 6.3. As stated before, the spatial regression adds a spatial lag factor that considers space relative to other spaces when conducting the regression. As this is the same spatial regression model as was shown in hypothesis one, the likelihood ratio test and r-squared results are the same. This model examines the spatial association between the neighborhood disadvantage scale and the built environment outlets, while controlling for the percentage of African-Americans living in a county and whether the county is urban or rural.

This spatial model is very similar to the linear regression model, concerning which variables are significant. In this model, only the association between the neighborhood disadvantage scale and positive food environment outlets is not significant. For every one-point increase in the neighborhood disadvantage scale, there is a 0.022 percentage point decrease in negative food environment outlets, a 0.025 percentage point decrease in healthcare facilities, a 0.029 percentage point decrease in physical activity facilities, and a 0.007 percentage point decrease in public administration facilities.

## 6.3 Hypothesis 1C. The built environment will vary based on the geographic density of the areas where people live.

### *6.3.1 Descriptive and Hot-Spot Analyses*

The third hypothesis tested in this chapter concerns the differences in geographic density and the resultant differences in the built environment. As stated in Chapter 4, differences in population density could affect the built environment, as areas with fewer people will generally have fewer resources. This is considered in this analysis. Counties designated as urban have an accessibility catchment area of one mile to each built environment facility, while areas designated as rural have a catchment area of ten miles.

The first map in Figure 6.14 shows which counties in Georgia are designated as urban and which as rural. Most the urban counties are those surrounding Atlanta and to the north. The rural areas are generally throughout the central and southern regions of Georgia. The second map shows the population density for each county. It ranges from a minimum of 8.5 people per square mile to nearly 2600 people in the same size area. In this map, the less dense areas are to the southwest, curving up through central Georgia to the counties surrounding Augusta. The exceptions are the counties in between that follow Interstate 75 to Florida. In general, however, the more densely populated areas are in the northern part of Georgia, while the less dense counties are in southern Georgia.

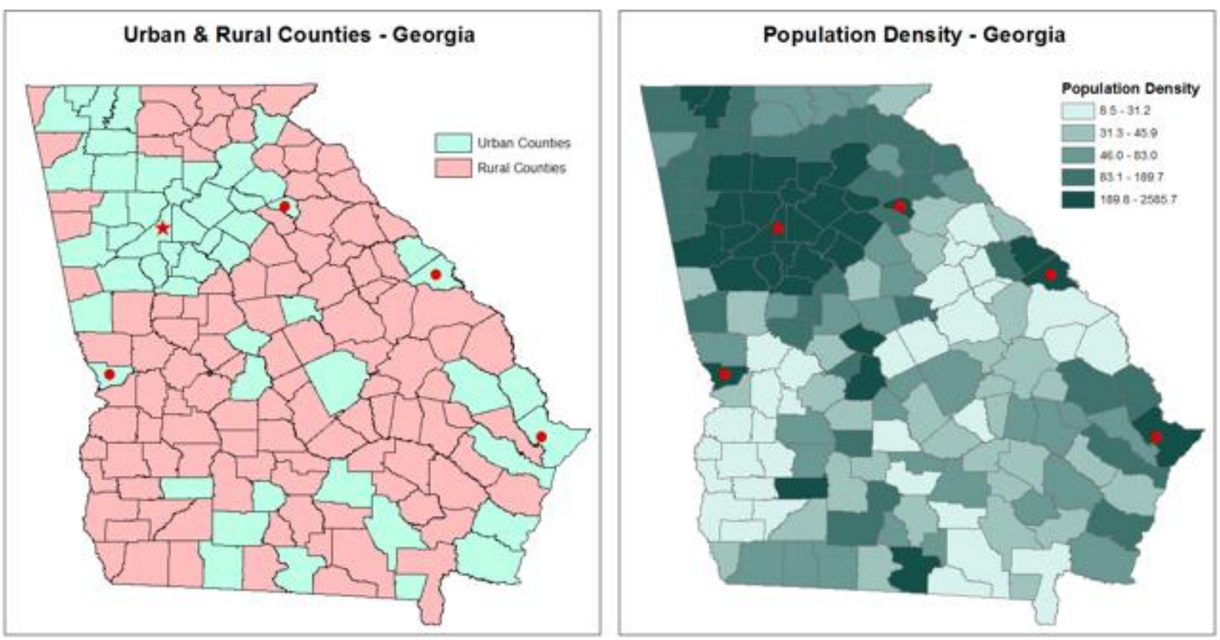



**Figure 6.14. Urban and Rural County Designations, Population Density of Georgia.**

As with the previous two hypotheses, the next set of maps (Figure 6.15) show population density by county overlaid by each built environment outlet. In the first map, positive food outlets are far more prevalent in areas of greater population density. This trend follows for both

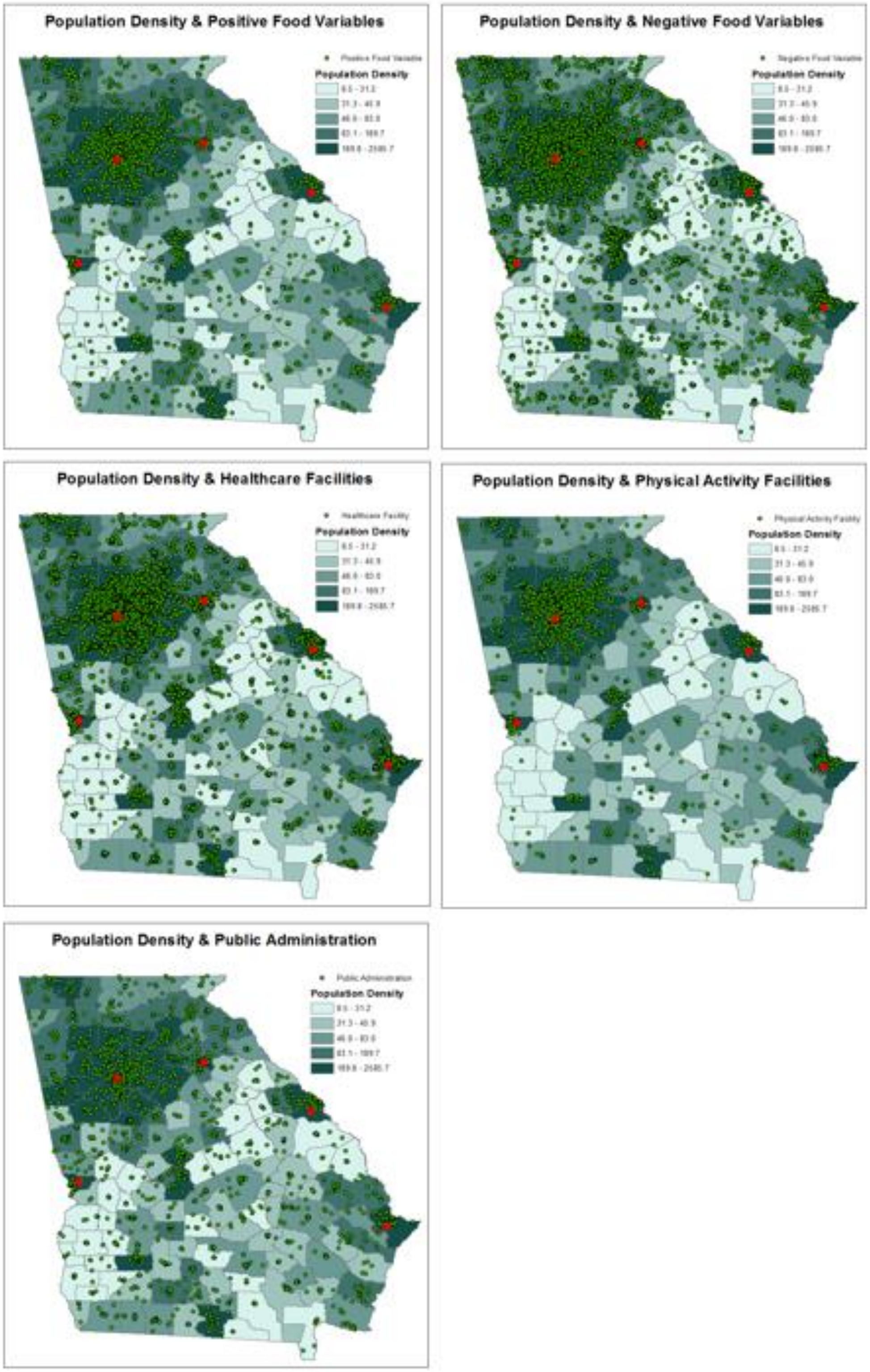



**Figure 6.15. Population Density and Measures of the Built Environment.**

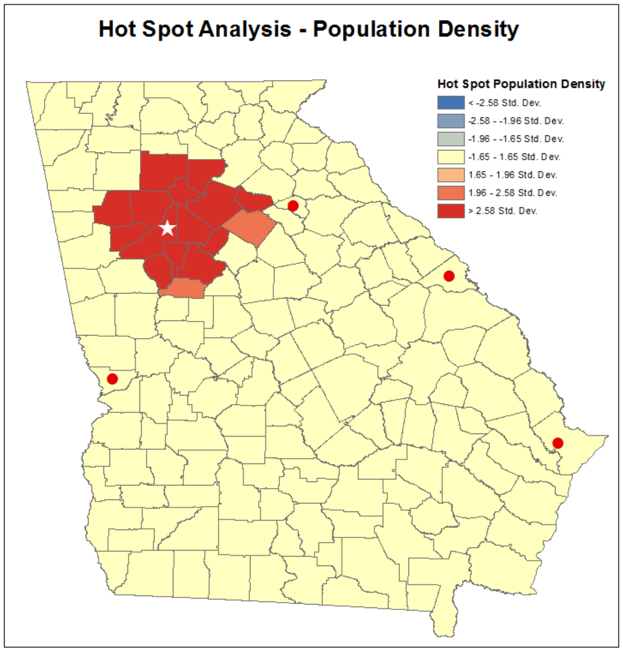



**Figure 6.16. Hot-spot Analysis of Population Density.**

negative food outlets and healthcare facilities, although negative food outlets still have a decent presence in less dense counties. Healthcare facilities are very prevalent in highly dense areas, although there is a solid presence of healthcare facilities in areas with fewer people. Physical activity facilities, however, are very much located in counties of higher population density, especially in the counties surrounding Atlanta and Savannah. Rural counties, or counties with fewer people per square mile, have very few, or no physical activity facilities at all. Finally, public administration is evenly distributed throughout each county, regardless of population density.

The map in Figure 6.16 shows the results of the hot-spot analyses conducted on the population density variable. Unlike previous hot-spot analyses, these maps only show significant clustering around the metro Atlanta area. What is interesting is that there are no counties that are considered 'cold-spots'. This means that even the least population-dense counties in Georgia,

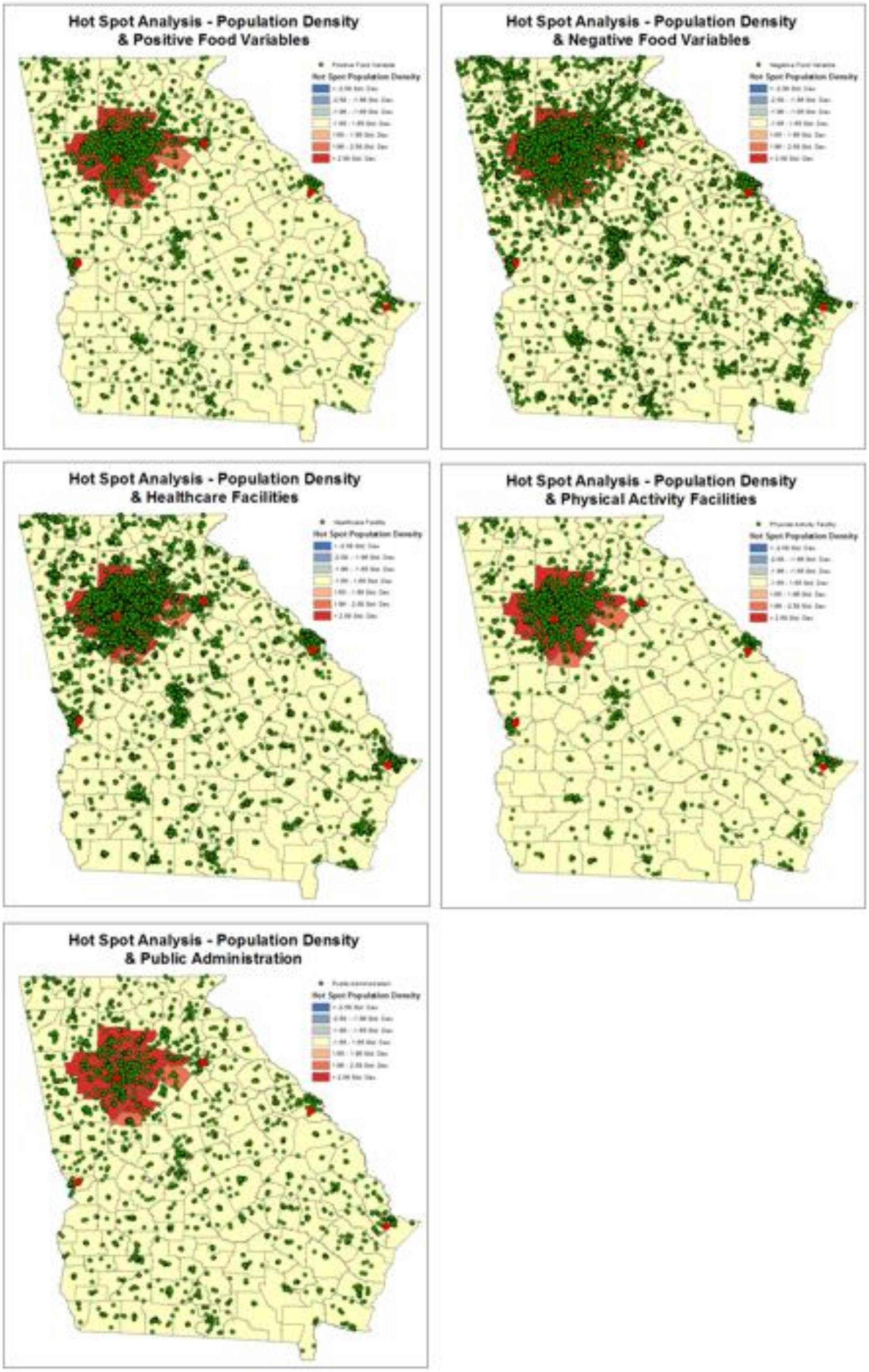



**Figure 6.17. Hot-spot Analysis of Population Density and Measures of the Built Environment.**

including Taliaferro, Clinch, and Echols counties are not low enough in population to be even one standard deviation below the norm.

In Figure 6.17, for positive food outlets, the hot-spot area is almost completely overwhelmed by green dots indicating either a supermarket or a grocery store. However, there are few clusters of positive food outlets outside of the Atlanta cluster. Negative food outlets follow the same pattern, to an extent, but there are many more clusters of facilities such as fast food restaurants and convenience stores. These cluster around Atlanta, but also around Macon in Bibb County, and around the other major cities in Georgia. These negative food outlets can also be seen trailing south in a straight line, following Interstate 75. Healthcare facilities are somewhat more evenly distributed, with a large group in Augusta and Savannah, while the bulk are in Atlanta. Finally, physical activity facilities appear to cluster around Atlanta, Macon, Augusta, and Savannah, but are relatively rare in other areas.

### *6.3.2 GB2SFCA Method Results*

The maps in Figure 6.18 show the results of the Gaussian-based two-step floating catchment area method of the accessibility of each built environment outlet overlaying population density. For positive food outlets, it is interesting to note that while these variables may not be prevalent in rural or less population-dense areas, they are generally located within ten miles of the population center of most counties in Georgia, indicating decent accessibility in rural areas. In fact, urban areas are less likely to have decent accessibility to positive food outlets than in a good portion of rural areas. Unfortunately, the same holds true for negative

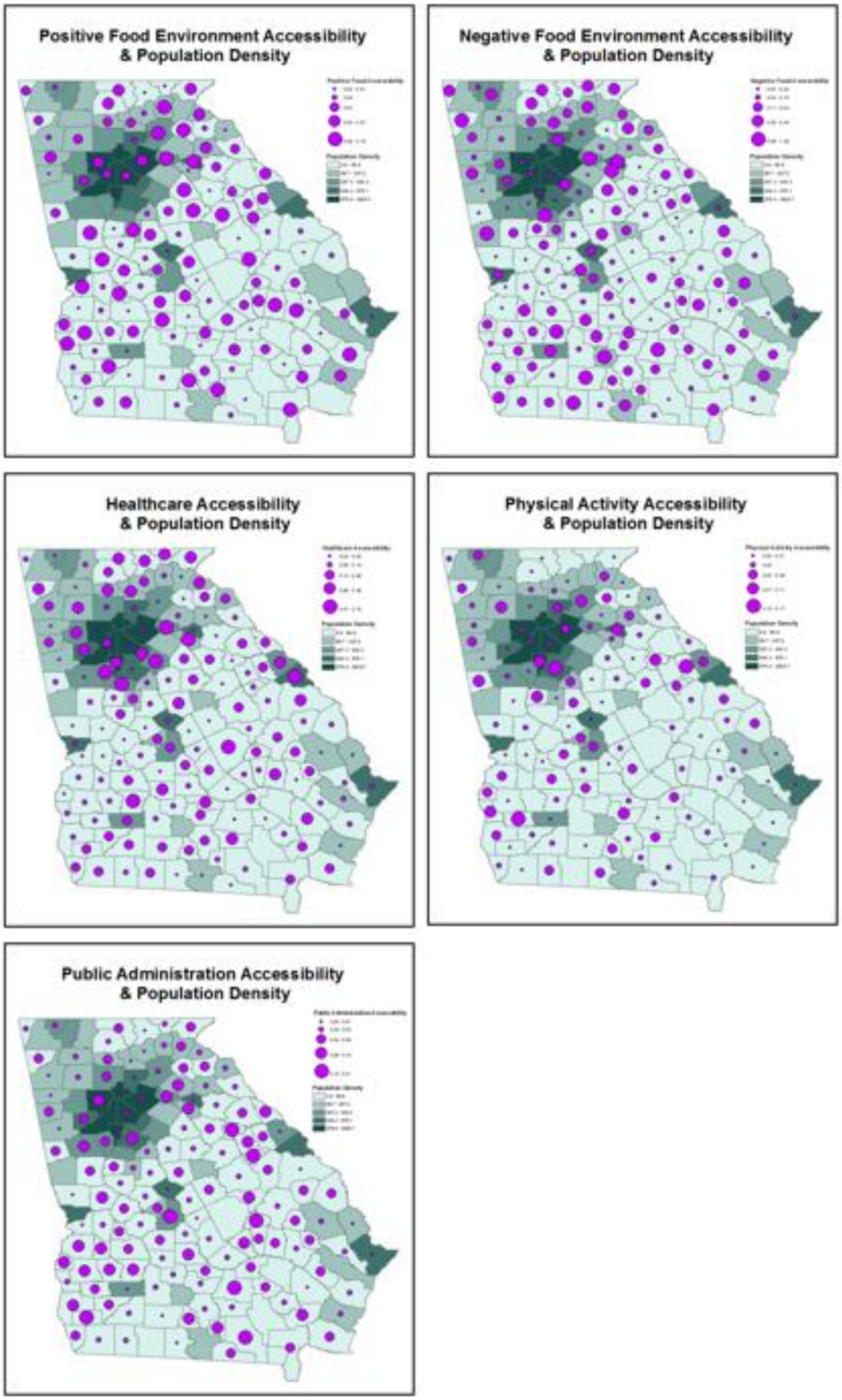



**Figure 6.18. Population Density and Built Environment Outlet Accessibility.**

food environment outlets as well. Areas of lowest accessibility to negative food outlets are the urban areas, while areas of lower population density have greater accessibility. Healthcare facilities do not seem to follow this trend. Healthcare facilities are in general, more likely to be more accessible to those living in higher density areas. Lower density areas have lower access to healthcare facilities. Physical activity facilities follow the same pattern, except for the counties just outside of Albany. In general, physical activity facilities are more accessible in areas of higher population density than in areas of lower density. Finally, for public administration, accessibility is evenly distributed, regardless of population density.

### *6.3.3 Linear Regression Results*

The results of the linear regression analysis are shown in Table 6.2. These regressions determine the extent to which the built environment varied based on whether the county is urban or rural. The ANOVA F-test statistics and r-squared results are the same as stated in the first hypothesis. For the regressions themselves, the main variable of interest is the association between urban and rural designation of each county and the built environment outlets. All five built environment outlets in these regressions are significant, indicating that urban or rural residence plays a meaningful role in the development of the built environment.

For positive food environment outlets, rural residence is associated with a 0.653 outlet decrease in positive food environment outlets. Rural residence is associated with a 1.034 outlet decrease in negative food environment outlets. Residents living in rural counties also have a 1.056 facility decrease in healthcare facilities and a 0.931 facility decrease in physical activity facilities. Finally, rural residence is associated with a 0.611 outlet decrease in public administration facilities.

#### *6.3.4 Spatial Regression Results*

The results of the regressions with the additional spatial weight added are shown in Table 6.3. These regressions examine the relationship between urban and rural status in a county and the built environment outlets. The spatial regression results look very similar to the linear regression results, except for public administration facilities. As before, the likelihood ratio test and r-squared results are the same as in the previous two hypotheses.

For urban or rural residence, all built environment outlets are statistically significant. Rural residence is associated with a 0.782 percentage point decrease in positive food environment outlets and a 0.908 percentage point decrease in negative food environment outlets. Those living in rural areas have 0.882 percent fewer healthcare facilities and 0.746 percent fewer physical activity facilities, on average, controlling for all other variables, than those living in urban areas. Finally, public administration facilities were 0.600 percent fewer in rural areas.

For the first question, I examined the extent to which sociodemographic factors such as race, income, and urban or rural status affected the presence of built environment facilities such as positive food environment, negative food environment, healthcare facilities, physical activity facilities, and public administration facilities. The results show almost unequivocally that the sociodemographic factors are in fact associated with the presence of the above built environment facilities. The theory of fundamental causes states that social factor are fundamental causes of poor health in vulnerable communities. This results section has shown that sociodemographic factors influence the built environment. Are these factors associated with diabetes prevalence, as hypothesized based on fundamental causes theory? Chapter 7 examines the association between sociodemographic factors, built environment facilities, and diabetes prevalence in Georgia.

# 7 RESULTS – HOW DO NEIGHBORHOOD COMPOSITION AND BUILT ENVIRONMENT TOGETHER INFLUENCE DIABETES PREVALENCE?

This chapter focuses on the extent to which the built environment plus neighborhood composition affect diabetes prevalence. Diabetes is a national problem, and Georgia ranks 41 out of 50 for diabetes prevalence in the United States (America's Health Rankings, 2015). The results of these analyses show how aspects of the built environment, such as the dissimilarity index, the neighborhood disadvantage index, and population density, along with the built environment outlets of the positive food environment, negative food environment, healthcare facilities, physical activity facilities, and public administration facilities are associated with diabetes prevalence at the county level in Georgia.

The hypotheses that were tested for this chapter consist of Question Two and the three sub-hypotheses listed in Table 4.1. Beginning with hypothesis 2A, it states that areas of higher African-American presence will have lower access to healthful facilities and a higher prevalence of diabetes. I examined the dissimilarity index and the percentage of African-Americans living within each county along with built environment outlets, and then examined diabetes prevalence, both spatially and non-spatially. Hypothesis 2B states that areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes. Using the neighborhood disadvantage index allowed me to examine the relationship between it and built environment facilities, and their resultant association with diabetes prevalence. Finally, the sixth hypothesis states that areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes. This was examined using urban or rural county designation, the built environment, and their relationship with diabetes prevalence.

## 7.1 Hypothesis 2A. Areas of higher African-American presence will have lower access to healthful facilities and a higher prevalence of diabetes.

### *7.1.1 Descriptive and Hot-Spot Analyses*

The results of the descriptive analyses are shown in Figure 7.1. The first map shows how counties rank for dissimilarity index. Areas in darker red have a higher level of proxy residential segregation in the form of the dissimilarity index. In these areas, a greater percentage (shown in legend) of African-Americans would have to move to achieve evenness among African-American and Caucasian residential neighborhoods. The areas in darker red tend to be primarily in the northern part of Georgia, while the south-central section of Georgia has a moderately low dissimilarity index score. Unfortunately, every major city in Georgia is in a county with a very high dissimilarity index score.

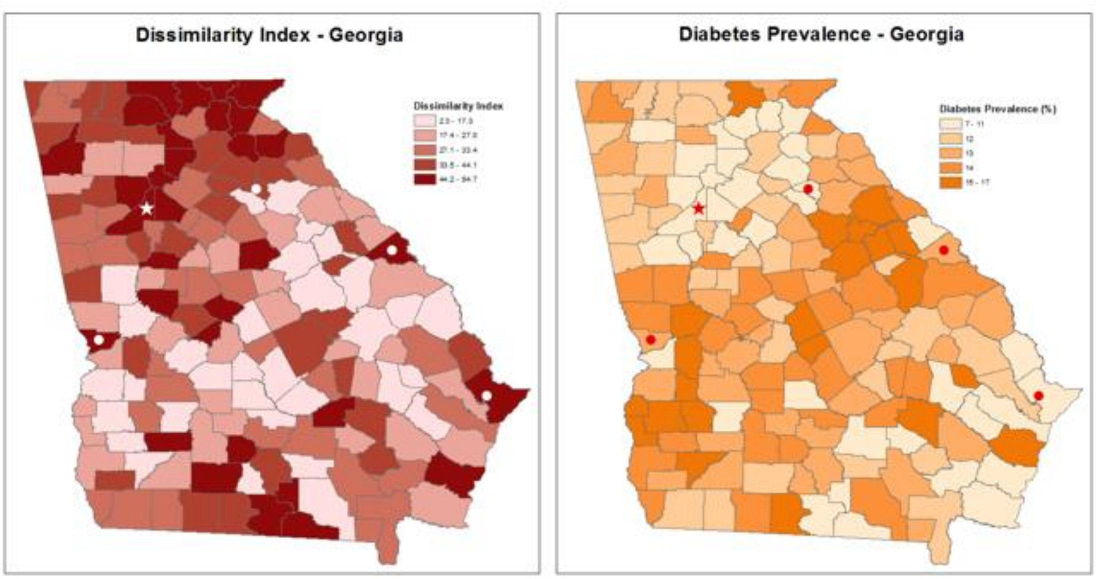



**Figure 7.1. Dissimilarity Index Scores and Diabetes Prevalence in Georgia.**

The second map shows diabetes prevalence throughout Georgia. The prevalence rates range from seven percent to seventeen percent. Areas of lowest diabetes prevalence are in the metro Atlanta area and stretch to the north. There is another significant portion of low diabetes prevalence in Savannah and the southern coastal counties. The areas of highest diabetes prevalence are in the same south-central swath of Georgia. It flows from the southwestern corner of Georgia up through the central area and to the eastern midsection. This can be considered Georgia's 'diabetes belt.' This is the area of highest concern for this project, as it is the area most vulnerable to diabetes prevalence. It is interesting to note that the second map is something of an inverse of the first map. Not in every case, but in general, areas of a high dissimilarity index score tend to have lower rates of diabetes. This first section will be the only one to highlight diabetes prevalence through maps, but will apply throughout the remainder of the hypotheses tested.

The next five maps in Figure 7.2 show the results of the dissimilarity index overlaid by the built environment outlets. This is to determine whether there is a distinct relationship between the two. These maps follow the same order as previous ones: the positive food built environment, the negative food built environment, healthcare facilities, physical activity facilities, and public administration facilities. For all but the negative food environment outlets, there appears to be little association between dissimilarity index and the locations of each type of variable. Interestingly, though, there seems to be a positive association between the negative food environment and the dissimilarity index. In areas that have higher dissimilarity index scores, there are more negative food environment facilities, such as fast food restaurants and convenience stores. In areas of lower dissimilarity index scores, there are some, but not nearly as many as in the higher scoring areas.

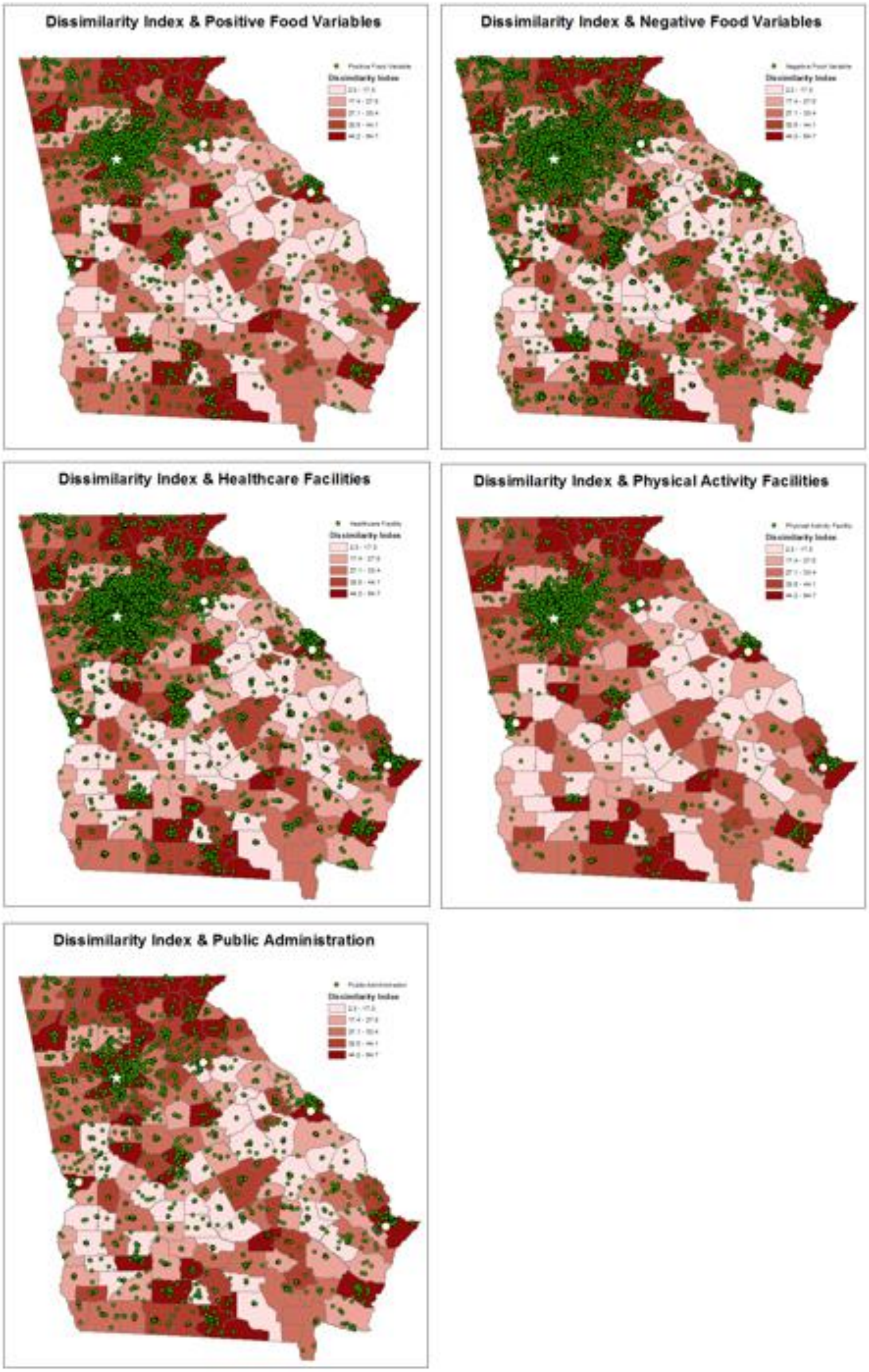



**Figure 7.2. Dissimilarity Index and Measures of the Built Environment.**

The second set of maps (Figure 7.3) show diabetes prevalence overlaid by each built environment outlet. For positive food outlets, in general the areas of lowest diabetes prevalence are the same areas with several supermarket or grocery store options. Areas of highest diabetes prevalence tend to have fewer positive food variable options. However, because these areas are also predominately in rural areas, the accessibility to these positive food outlets may be greater than in urban areas with potentially greater options. For negative food environment outlets, the clear majority of them also appear to be in areas of lowest diabetes prevalence. However, there do tend to be more negative than positive food environment outlets in all areas, but especially in areas of higher diabetes prevalence. For healthcare facilities, there is a distinct difference in areas of low versus high diabetes prevalence. Areas of high diabetes prevalence have significantly fewer healthcare facilities available to the residents who live there. The same tendency is apparent with physical activity facilities. There are many facilities in areas immediately surrounding the five major cities in Georgia, but other than that, they are few and far between. Multiple counties with the highest diabetes prevalences do not have any physical activity facilities at all. Finally, public administration facilities, as stated before, act as almost a 'control' built environment outlet, as it shows what the built environment could look like if other variables were distributed evenly as well. In saying, public administration facilities do not have any apparent association with diabetes prevalence. Areas of high and low diabetes prevalence tend to have relatively similar public administration facilities available to the residents who live there.

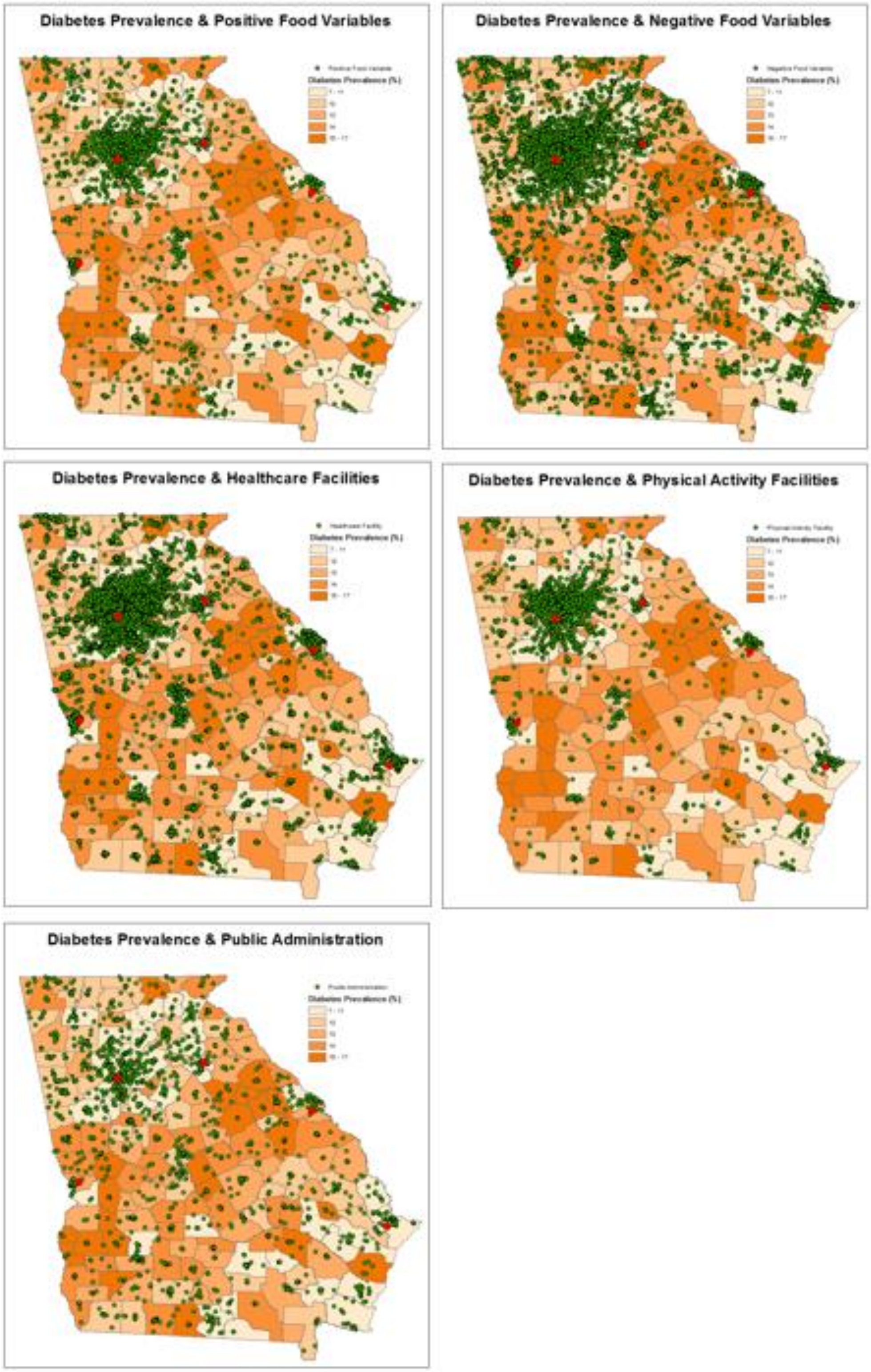



**Figure 7.3. Diabetes Prevalence and Measures of the Built Environment.**

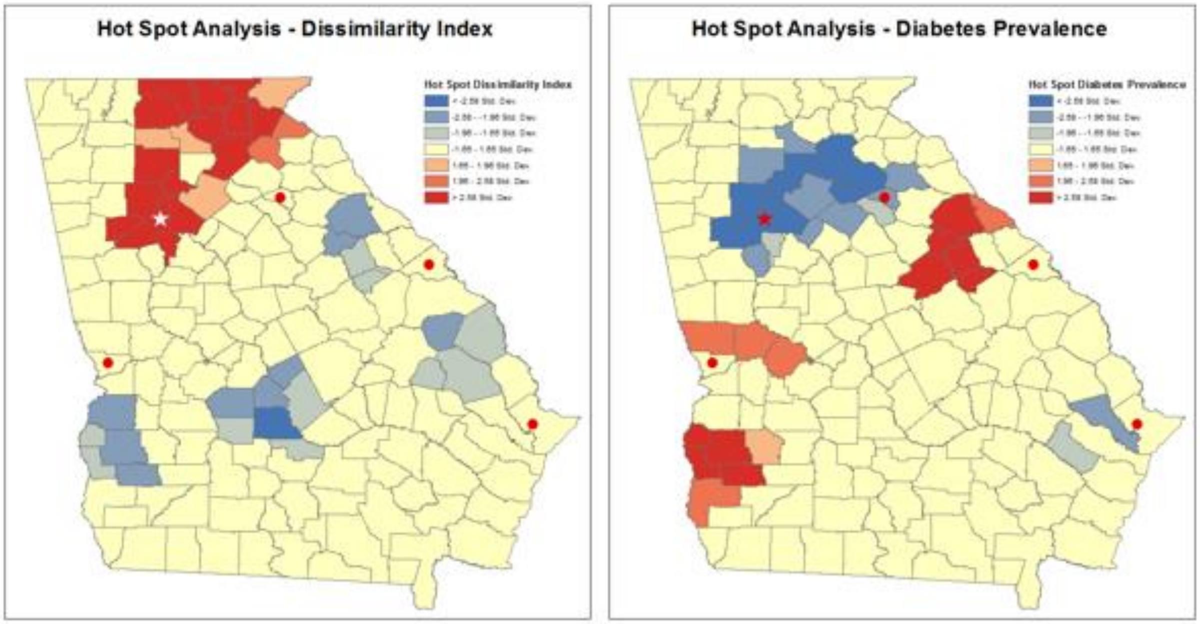



**Figure 7.4. Hot-spot Analysis of Dissimilarity Index and Diabetes Prevalence.**

The maps in Figure 7.4 show the hot-spot analyses for both the dissimilarity index and diabetes prevalence. As before, diabetes prevalence will be discussed here, but referenced in the remainder of the chapter. Hot-spot areas of high dissimilarity are centered around Atlanta and move to the northern part of Georgia. The cold spots of low dissimilarity are in the southern and central parts of Georgia, and follow the diabetes belt across the southwest to central east section of the state. The hot-spot analysis of diabetes prevalence shows that the hot-spots are in the southwestern section of Georgia, the counties just north of Columbus, and the few counties between Athens and Augusta, following loosely the same diabetes belt.

The maps in Figure 7.5 show the hot-spot analyses overlaid by the built environment outlets. For all variables, there does not seem to be an association between the location of each built environment outlet and the clusters or hot-spots of high or low dissimilarity. The

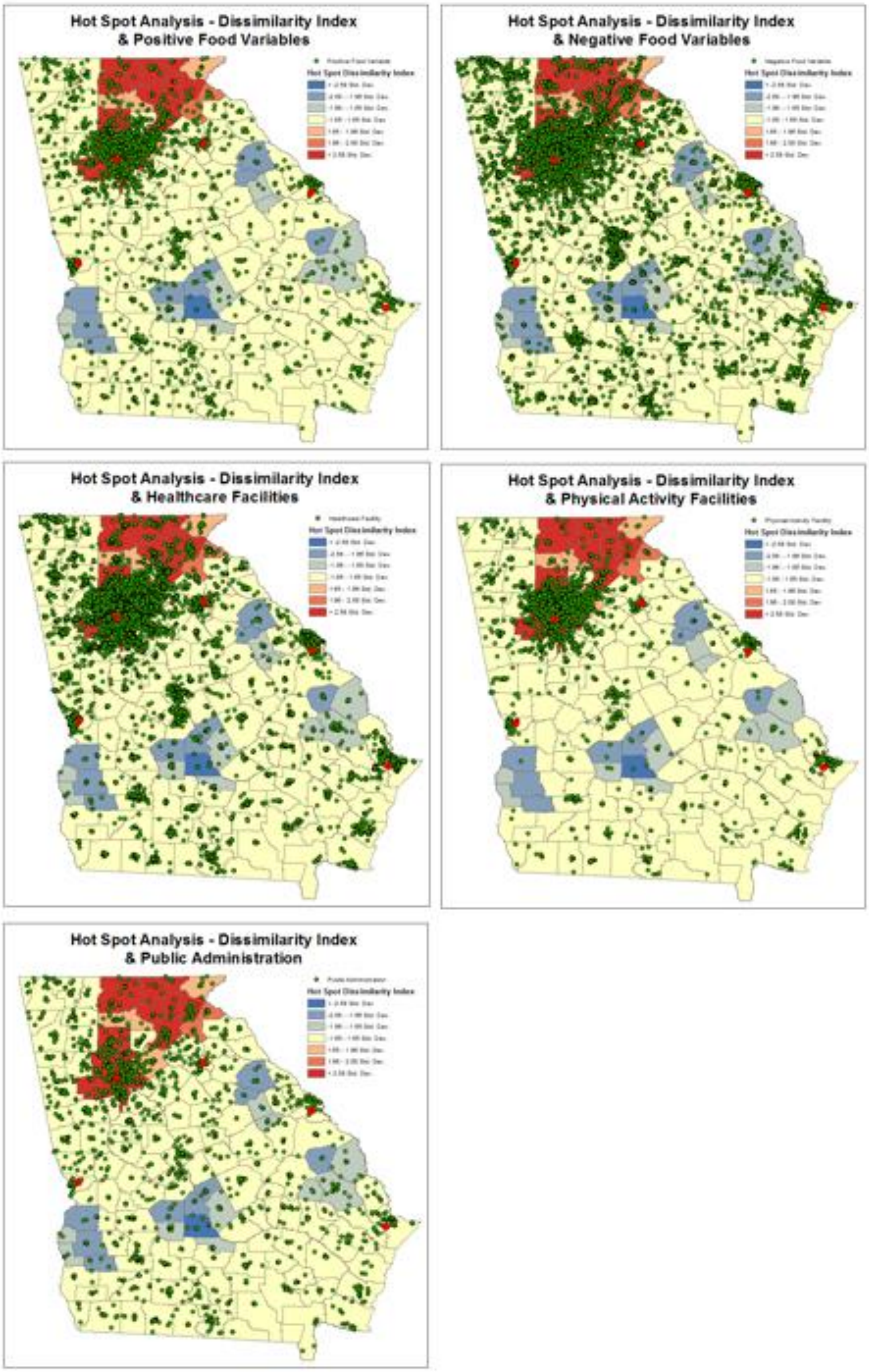



**Figure 7.5. Hot-spot Analysis of Dissimilarity Index and Measures of the Built Environment.**

low dissimilarity counties have a similar number of each built environment facility as the high dissimilarity counties.

The next maps show the hot-spot analyses of diabetes prevalence overlaid by the built environment outlets. Here, there is a distinct association between areas of low diabetes prevalence and high availability to every built environment facility. Although negative food outlets are more available in areas throughout the state as opposed to positive food outlets, healthcare facilities and physical activity facilities, they are also more prevalent in areas of low diabetes prevalence as well. Most particularly is the disparity noticed for physical activity facilities. Areas of the highest diabetes prevalence have extremely few physical activity facilities, while they dominate the areas of low diabetes prevalence. As always, public administration is evenly distributed, and there is not a visually distinct relationship between diabetes prevalence and public administration facilities.

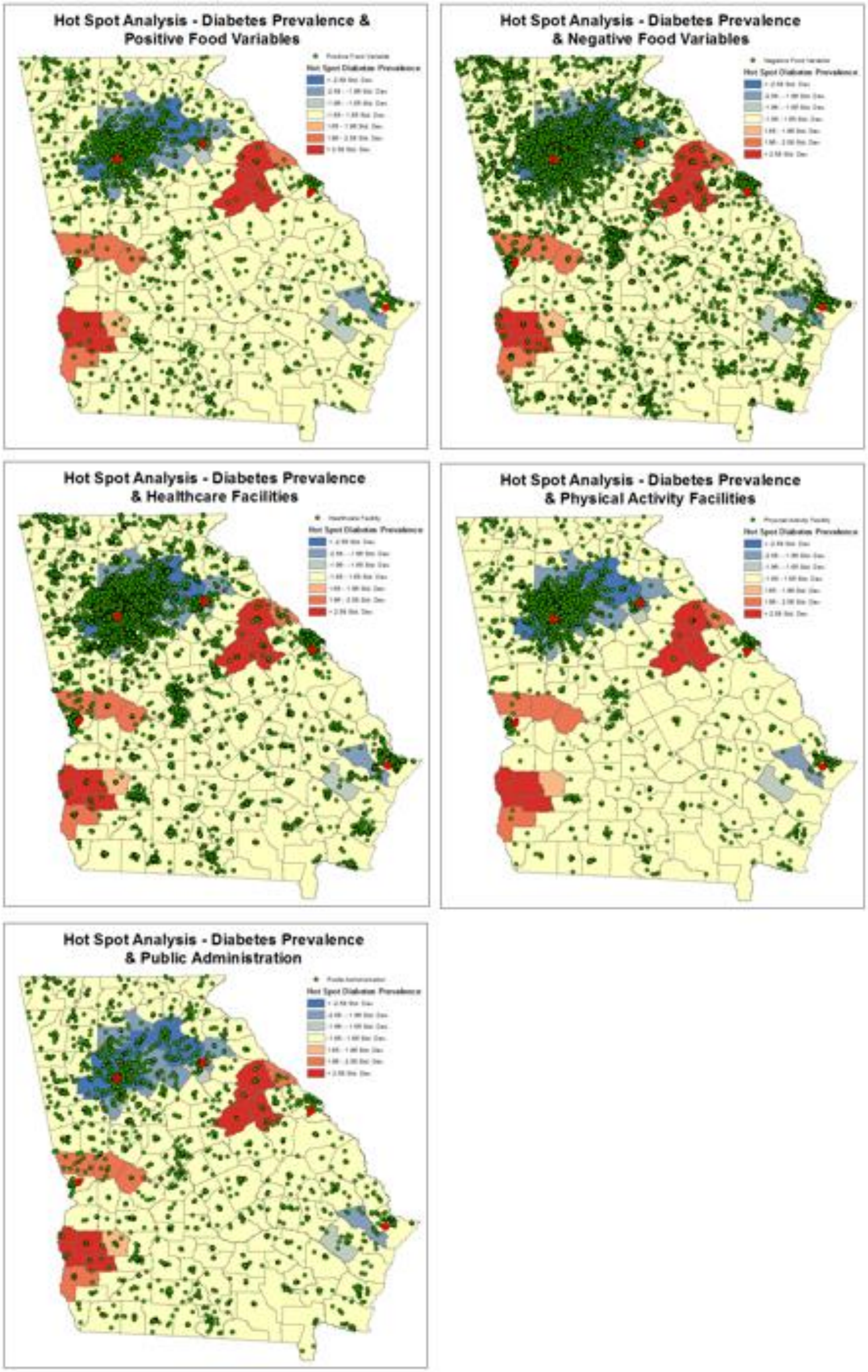



**Figure 7.6. Hot-spot Analysis of Diabetes Prevalence and Measures of the Built Environment.**

### *7.1.2 GB2SFCA Method Results*

The results of the GB2SFCA method results are below in Figures 7.7 and 7.8. The first set of maps (Figure 7.7) show the results of the accessibility of each built environment outlet overlaying the dissimilarity index. For positive food outlets, negative food outlets, physical activity facilities, and public administration, there does not seem to be a distinct association between each built environment outlet and the dissimilarity index. However, for healthcare facilities, it shows that, in general, areas of low dissimilarity have low access to healthcare facilities, while areas of medium to high dissimilarity have greater access to healthcare facilities.

Perhaps the most important maps in this dissertation are those that appear in Figure 7.8. These maps show the relationship between the accessibility between positive food outlets, negative food outlets, healthcare facilities, physical activity facilities, and public administration facilities and diabetes prevalence. For positive food outlets, there seems to be an association between areas of high diabetes prevalence and accessibility to supermarkets and grocery stores. However, keep in mind that these maps show accessibility, not availability. Interestingly though, even though some counties with the highest diabetes rates do not have many positive food outlets, those that are there are ones that are easily accessible for the population centers of those counties. For negative food outlets, there does not seem to be much of a visual association between negative food outlets and diabetes prevalence. Good accessibility to negative food outlets appears in counties of both low and high diabetes prevalence. Healthcare facilities are negatively associated with diabetes prevalence. In just about every case, in areas of low diabetes prevalence, healthcare facilities are easily accessible. Conversely, in areas of high diabetes prevalence, healthcare facilities are not very accessible at all. Physical activity facilities do not appear to be highly correlated with diabetes prevalence.

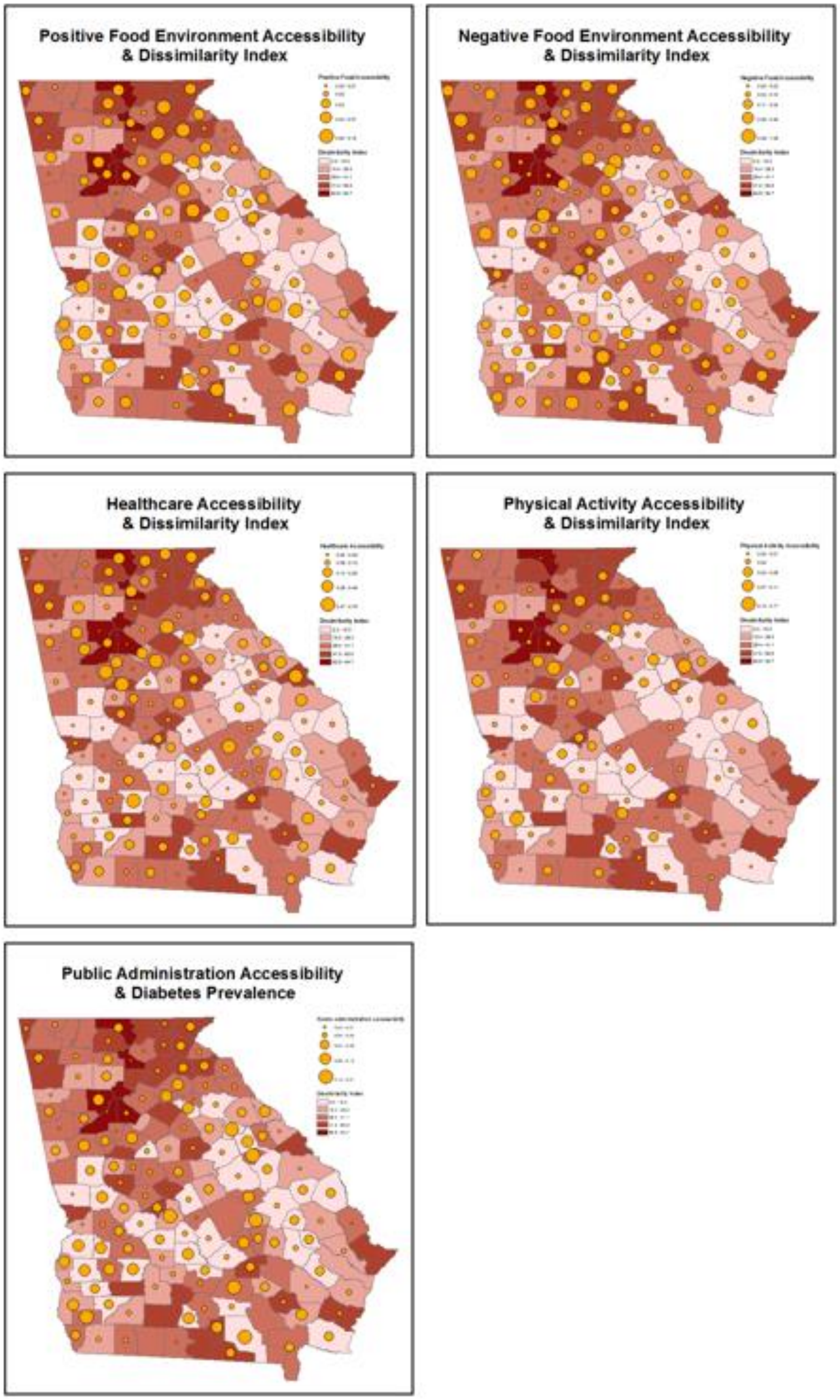



**Figure 7.7. Dissimilarity Index and Measures of the Built Environment.**

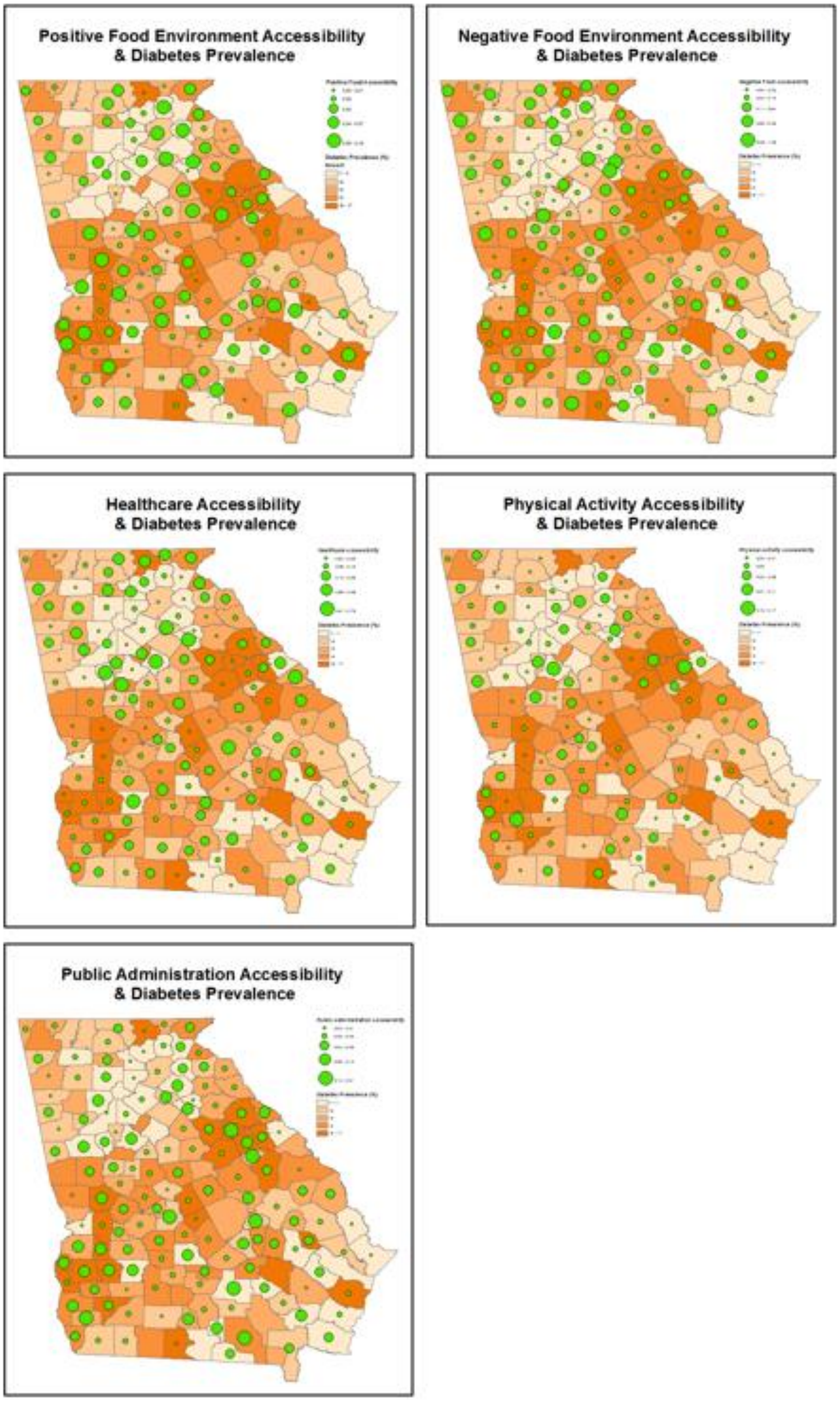



**Figure 7.8. Diabetes Prevalence and Measures of the Built Environment.**

Some areas of high diabetes prevalence do have high accessibility to physical activity facilities, and some areas of low diabetes prevalence do not have access to physical activity facilities. Finally, public administration appears to be more accessible in areas of high diabetes prevalence over areas of low diabetes prevalence. This is not the case in every county, but in general, the highest accessibility in public administration facilities lies in the diabetes belt area, where the highest rates of diabetes exist as well. Overall, most of the built environment outlets do show some correlation, either positive or negative, with diabetes prevalence in counties throughout Georgia.

### *7.1.3 Linear Regression Results*

The results of the linear regression analysis are shown in Table 7.1. In these regressions, I examined the relationship between the five built environment outlets, the percentage of African-Americans in a county, the neighborhood disadvantage scale, urban or rural residence, and diabetes prevalence. The ANOVA F-test results for all five regressions were significant, indicating that the models were good fits for the data. The r-squared, the statistic that determines how much of the variation between the variables is explained by the model, ranges between 0.270 for positive food environment outlets to 0.421 for negative food environment outlets.

Overall, higher African-American presence in a county is significantly associated with higher diabetes prevalence before introducing the built environment outlets. In four of the five regressions (negative food environment outlets, healthcare facilities, physical activity facilities, and public administration facilities), the pertinent built environment outlet is statistically significant. For every one percentage point increase in African-American population, diabetes

**Table 7.1. Linear Regression of Hypothesis #4.**

| Independent Variables | | Dependent Variable | | | | |
|---|---|---|---|---|---|---|
| | | Diabetes Prevalence | | | | |
| | | | | | | |
| Positive Food Outlets | | -0.443 | | | | |
| | | [-0.099] | | | | |
| | | (0.681) | | | | |
| Negative Food Outlets | | | **-0.309*** | | | |
| | | | [-0.261] | | | |
| | | | (0.086) | | | |
| Healthcare Facilities | | | | **-0.249*** | | |
| | | | | [-0.239] | | |
| | | | | (0.075) | | |
| Physical Activity | | | | | **-0.234*** | |
| | | | | | [-0.241] | |
| | | | | | (0.069) | |
| Public Administration | | | | | | **-0.710*** |
| | | | | | | [-0.246] |
| | | | | | | (0.218) |
| African-American (%) | **0.019*** | 0.009 | **0.028*** | **0.027*** | **0.026*** | **0.025*** |
| | [0.196] | [0.096] | [0.279] | [0.275] | [0.265] | [0.252] |
| | (0.008) | (0.013) | (0.008) | (0.008) | (0.008) | (0.008) |
| Neighborhood Disadvantage Scale | **0.041*** | **0.052*** | **0.030*** | **0.031*** | **0.030*** | **0.035*** |
| | [0.361] | [0.427] | [0.269] | [0.271] | [0.268] | [0.307] |
| | (0.011) | (0.018) | (0.011) | (0.011) | (0.011) | (0.010) |
| Urban or Rural Residence | **0.792*** | -0.016 | 0.472 | 0.529 | 0.574 | 0.358 |
| | [0.205] | [-0.099] | [0.122] | [0.136] | [0.148] | [0.092] |
| | (0.295) | (0.681) | (0.298) | (0.297) | (0.293) | (0.316) |
| | | | | | | |
| Intercept | 7.779 | 9.169 | 8.987 | 8.849 | 8.813 | 9.216 |
| | (0.546) | (1.502) | (0.625) | (0.621) | (0.609) | (0.690) |
| R-Squared | 0.373 | 0.270 | 0.421 | 0.414 | 0.417 | 0.413 |
| Adjusted R-Squared | 0.361 | 0.228 | 0.406 | 0.399 | 0.402 | 0.398 |
| ANOVA F-Test | **30.715*** | **6.395*** | **28.013*** | **27.247*** | **27.552*** | **27.110*** |

Note: Unstandardized coefficients (b) are listed first; standardized coefficients (β) appear in brackets; standard error ($SE_b$) appear in parentheses.
* $p \leq 0.05$

prevalence increases by 0.019 percentage points, on average. Once the built environment variables are introduced, the percentage of African-Americans in a community continues to be significant for every variable but positive food environment outlets, ranging from 0.025 to 0.028 percentage point increases in diabetes prevalence, on average. For every one-unit increase in negative food environment outlets, diabetes decreases by 0.309 outlets. Healthcare facilities and physical activity facilities are significantly associated with a 0.249 and 0.234 percentage point decrease in diabetes prevalence, respectively. Finally, for every one facility increase in public administration facilities, diabetes prevalence decreases by 0.710 percentage points, on average, controlling for all other variables.

### *7.1.4 Spatial Regression Results*

The results of the spatial regression analysis are shown in Table 7.2. While similar to the linear regression, in these models, all the built environment outlets are significant. However, the likelihood ratio test for each regression is nonsignificant, indicating that something other than space can better explain the relationship of the variables to each other. As diabetes is not a spatially-located variable, it is not surprising that the likelihood ratio tests are insignificant.

As with the linear regression model, the percentage of African-Americans living a county is significantly associated with diabetes prevalence before introducing the built environment outlets. For each one percentage point increase in African-American presence in a county, diabetes prevalence increases by 0.017 percentage points. It continues to be significant after introducing the built environment variables. After this introduction, every one percent increase in African-American population is associated with between a 0.023 and 0.026 percentage point increase in diabetes prevalence, on average.

**Table 7.2. Spatial Regression of Hypothesis #4.**

| Independent Variables | | Dependent Variable (%) | | | | |
|---|---|---|---|---|---|---|
| | | Diabetes Prevalence | | | | |
| | | | | | | |
| Positive Food Variables (%) | | **-0.307*** | | | | |
| | | [-3.196] | | | | |
| | | (0.961) | | | | |
| Negative Food Variables (%) | | | **-0.296*** | | | |
| | | | [-3.430] | | | |
| | | | (0.086) | | | |
| Healthcare Facilities (%) | | | | **-0.237*** | | |
| | | | | [-3.146] | | |
| | | | | (0.075) | | |
| Physical Activity (%) | | | | | **-0.224*** | |
| | | | | | [-3.267] | |
| | | | | | (0.685) | |
| Public Administration (%) | | | | | | **-0.676*** |
| | | | | | | [-3.120] |
| | | | | | | (0.217) |
| African-American (%) | **0.017*** | **0.025*** | **0.026*** | **0.025*** | **0.025*** | **0.023*** |
| | [2.113] | [.3.074] | [3.153] | [3.065] | [3.008] | [2.860] |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Neighborhood Disadvantage Scale | **0.037*** | **0.030*** | **0.029*** | **0.029*** | **0.029*** | **0.033*** |
| | [3.578] | [2.871] | [2.743] | [2.735] | [2.711] | [3.156] |
| | (0.010) | (0.010) | (0.010) | (0.011) | (0.011) | (0.010) |
| Urban or Rural Residence | **0.710*** | 0.449 | 0.437 | 0.490 | 0.532 | 0.324 |
| | [2.412] | [1.505] | [1.474] | [1.657] | [1.822] | [1.038] |
| | (0.294) | (0.298) | (0.296) | (0.295) | (0.292) | (0.313) |
| | | | | | | |
| Intercept | 6.362 | 8.054 | 8.084 | 7.891 | 7.864 | 8.202 |
| | (1.119) | (1.193) | (1.171) | (1.173) | (1.159) | (1.216) |
| R-Squared | 0.384 | 0.420 | 0.425 | 0.419 | 0.421 | 0.418 |
| Likelihood Ratio Test | 2.066 | 0.666 | 0.750 | 0.849 | 0.843 | 0.924 |

Note: Unstandardized coefficients (b) are listed first; z-scores appear in brackets; standard error ($SE_b$) appear in parentheses.
* $p \leq 0.05$

For every one percent increase in positive food outlets, diabetes prevalence decreased by 0.309 percentage points. Negative food environment and healthcare facilities are associated with a 0.296 and 0.237 percentage point decrease in diabetes prevalence, respectively. Each additional physical activity facility is associated with a 0.224 percentage point decrease in diabetes prevalence. Finally, for every one facility increase in public administration, there is a 0.676 percentage point decrease in diabetes prevalence, on average.

## 7.2 Hypothesis 5. Areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes.

### *7.2.1 Descriptive and Hot-Spot Analyses*

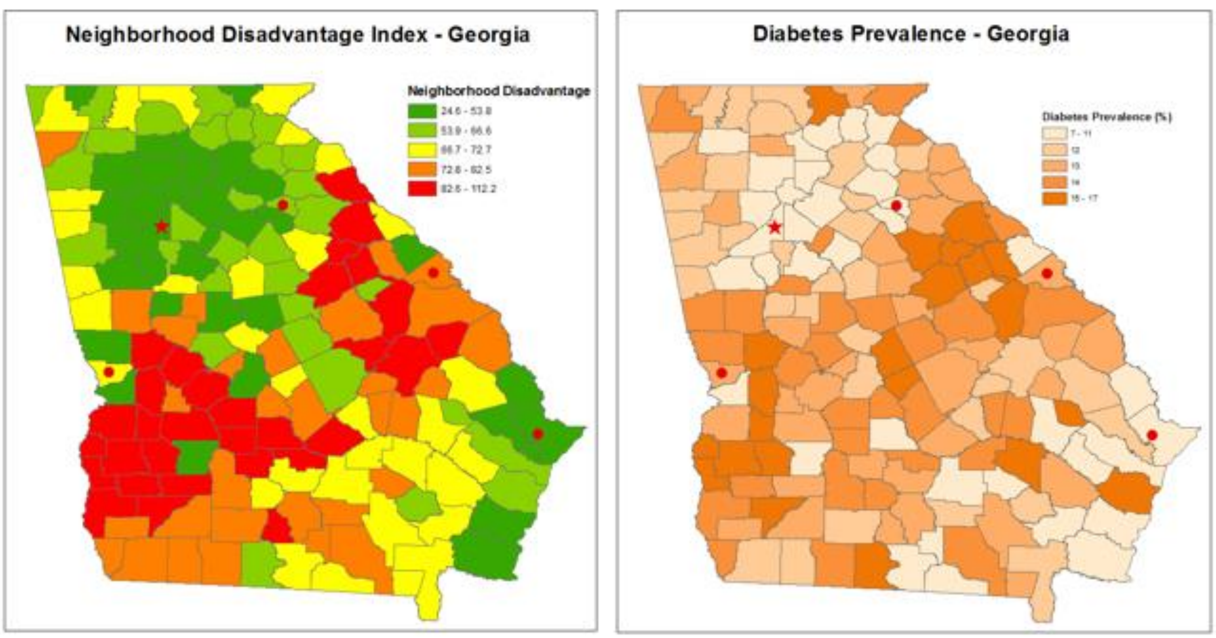



**Figure 7.9. Neighborhood Disadvantage Index and Diabetes Prevalence.**

The results of the analysis for hypothesis 2B are shown in Figure 7.9. The first map shows the neighborhood disadvantage index scores for counties throughout Georgia. Green counties have the lowest neighborhood disadvantage, while orange and red counties are the areas with the highest disadvantage. Neighborhood disadvantage takes into consideration the percentage of households receiving public assistance, the percent of adult unemployment in the area, and the percentage of families with more than $30,000 in annual income (reverse-coded). As shown in the map, most of the areas in green are in the northern section of Georgia and along the eastern coast. The areas in red are predominately in the southwest corner of Georgia, reaching up through the central eastern section. This map is contrasted with the second map, diabetes prevalence. Visually, there appears to be a strong positive association between neighborhood disadvantage and diabetes prevalence. That is, the counties that score lowest on the neighborhood disadvantage scale also have the highest rates of diabetes prevalence, and vice versa.

The next group of maps show neighborhood disadvantage overlaid by the built environment outlets. For four of the five built environment outlets, there is a strong association between the amount of each variable available in the county and its neighborhood disadvantage index score. For positive food outlets, the neighborhood disadvantage areas in green (indicating neighborhood advantage) have many more supermarkets and grocery stores available to their residents than areas in yellow, orange, and red. The same is true for negative food outlets, but there are more negative food outlets available in 'red' counties than positive food outlets. Healthcare facilities are very strongly located in areas of greater advantage. The areas in red and orange have very few healthcare facilities compared to areas in green. Finally, physical activity facilities follow the same pattern. Physical activity facilities are nearly exclusively located in 'green' counties. Areas of highest disadvantage have very few physical activity facilities available, if there are any at all. Public administration facilities are the sole built environment outlets that do not seem to follow the stark pattern. As they are well distributed throughout

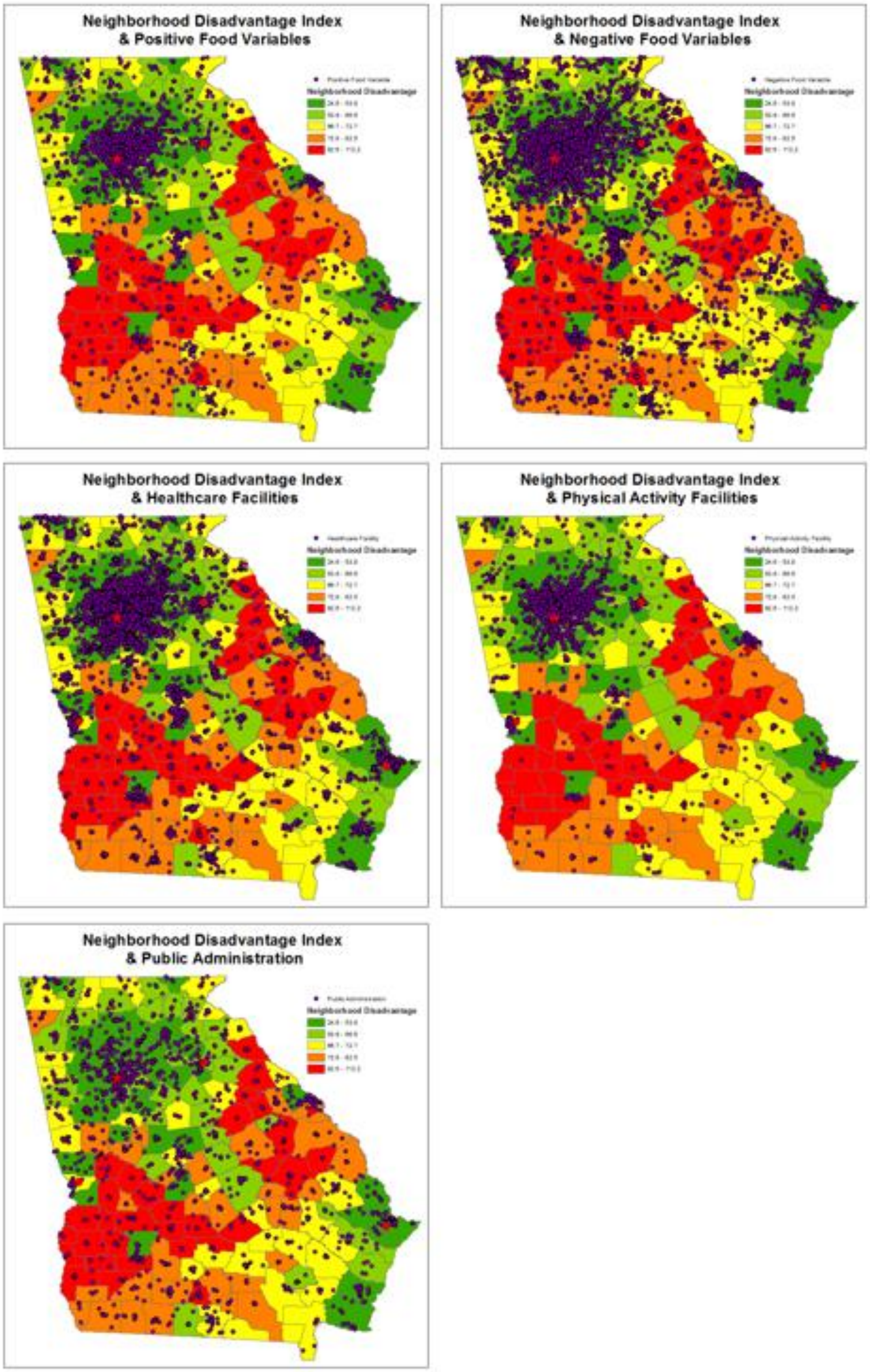



**Figure 7.10. Neighborhood Disadvantage Index and Measures of the Built Environment.**

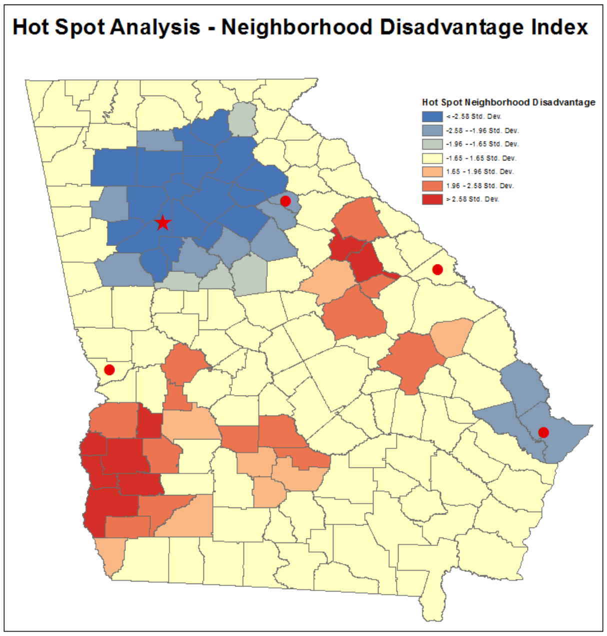



**Figure 7.11. Hot-spot Analysis of Neighborhood Disadvantage Index.**

the state, there is no apparent visual association between public administration facilities and neighborhood disadvantage index scores at the county level.

The next map in Figure 7.11 show the results of the hot-spot analyses for neighborhood disadvantage index. This can be compared to the results of each analysis for diabetes prevalence available in the previous section (Figure 7.4). The map shows the results of the hot-spot analysis of neighborhood disadvantage. This shows a greater range of neighborhood disadvantage scores, and range from two standard deviations below the mean to two standard deviations above the mean. The 'cold' areas are again, the counties in and around metro Atlanta and Savannah, while the 'hot' areas are in the southwest section, reaching northeast to the mid-eastern section of Georgia. Again, this is similar to the diabetes prevalence hot-spot analysis results, in that areas that are cold there are cold here, and areas that are hot there are hot here. For the hot-spot analyses, the neighborhood disadvantage significant counties are more numerous than the diabetes prevalence ones, but almost all that are included in the diabetes prevalence maps are included here.

The next maps show the hot-spot analyses (Figure 7.12) overlaid by the built environment outlets. As with the first group of descriptive maps, there is a strong association between neighborhood disadvantage and locations of built environment outlets. They are shown in greater contrast with these maps. For the first four built environment outlets, areas in blue have many more positive food environment outlets, negative food environment outlets, healthcare facilities, and physical activity facilities than in black or red counties. This is most particularly evident with positive food outlets, healthcare facilities, and physical activity facilities. For positive food outlets and physical activity facilities, a couple of the counties in black (or red) do not have any of these facilities at all. Public administration facilities, as usual, are distributed quite evenly, and do not show an association between their locations and neighborhood disadvantage index score at the county level in Georgia. These maps match up well with the hot-spot and built environment diabetes prevalence maps shown in Figures 7.4. In those, the locations of built environment outlets were associated with low diabetes prevalence. Areas of high diabetes prevalence had few, if any, facilities available to the residents of those counties.

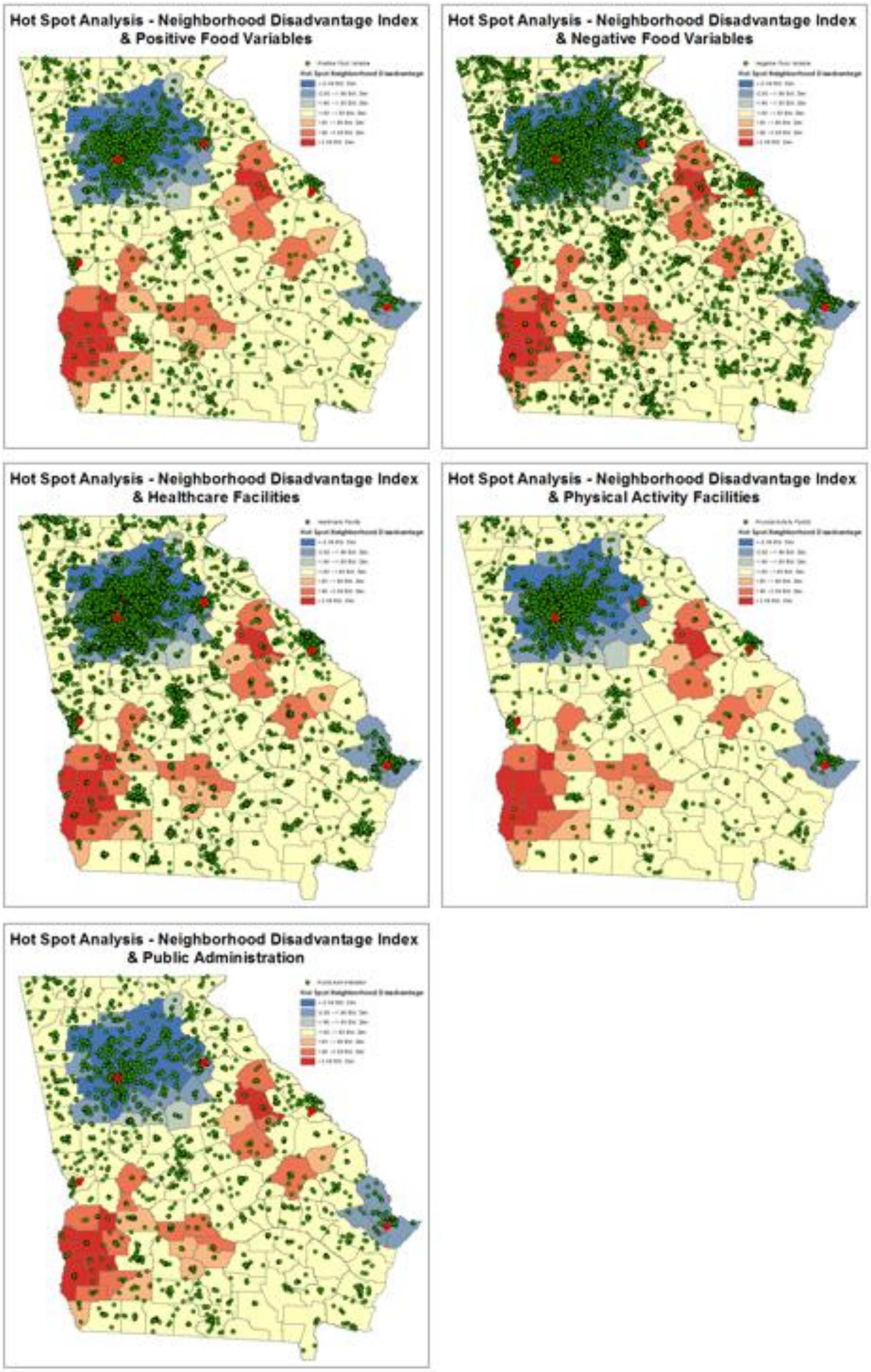



**Figure 7.12. Hot-spot Analysis of Neighborhood Disadvantage Index and Measures of the Built Environment.**

### *7.2.2 GB2SFCA Method Results*

The results of the GB2SFCA method results on each built environment outlet overlays the descriptive results of the neighborhood disadvantage index scores. The first map shows positive food environment accessibility associated with neighborhood disadvantage. While there are numerous green counties with high accessibility, there are also quite a few red counties with high accessibility as well, particularly in the southwest corner of Georgia. Indeed, there appear to be a nearly equal amount of highly accessible positive food environment outlets in the green and red counties. Negative food environment outlets are more easily accessible in areas in red and orange than in areas of green. This is concerning, because it indicates that residents in these areas can easily access fast food restaurants, convenience stores, and the like. Healthcare facilities show the opposite trend. Healthcare facility accessibility is greater in green areas than in red or orange. This means that areas of higher disadvantage have less accessibility to healthcare facilities in their area. Physical activity accessibility, with a few exceptions, shows the same pattern. The main exception is Calhoun County, which is an area of high disadvantage, but also has high accessibility to physical activity facilities. In general, though, areas of highest accessibility for physical activity facilities are in counties of lowest disadvantage. Finally, public administration facilities follow the same pattern as it has for every other hypothesis. In general, nearly every county has decent access to their public administration facilities, regardless of neighborhood disadvantage index score.

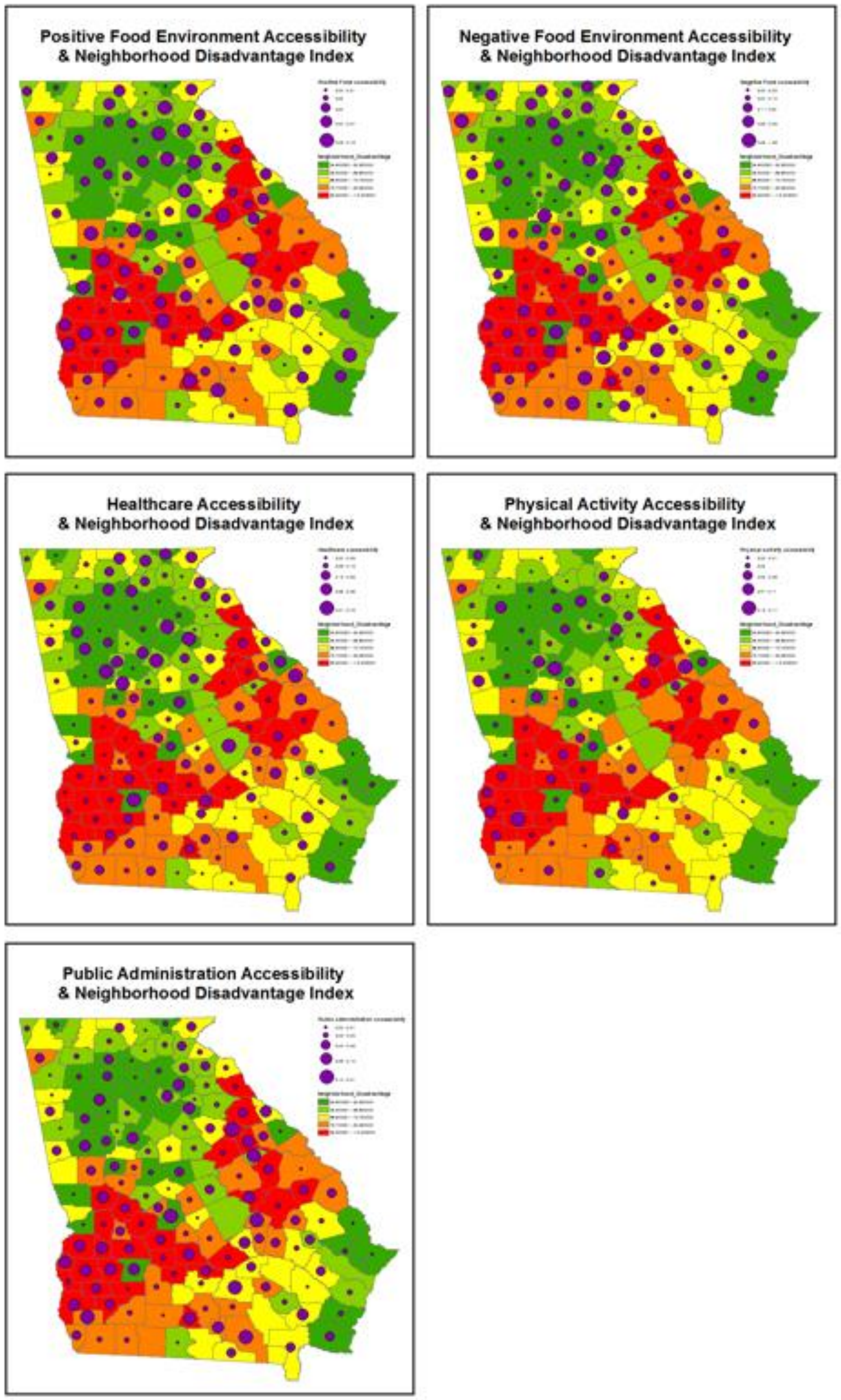



**Figure 7.13. Neighborhood Disadvantage Index and Measures of the Built Environment.**

### *7.2.3 Linear Regression Results*

The results of the linear regression analyses are shown in Table 7.1. The ANOVA F-test and r-squared results are the same as in hypothesis 2A. Neighborhood disadvantage scale is significantly positively associated with diabetes prevalence. As a high neighborhood disadvantage scale constitutes a worse neighborhood situation, and higher diabetes prevalence is undesirable as well, this positive association makes sense. For every one-point increase in the neighborhood disadvantage scale, there is an associated 0.041 percentage point increase in diabetes prevalence, before the introduction of the built environment variables. The association continues to be significant after all the built environment outlets are introduced. The positive food environment is associated with a 0.052 percentage point increase, the negative food environment and physical activity facilities are associated with an 0.030 percentage point increase, healthcare facilities are associated with a 0.031 percentage point increase, and public administration facilities are associated with a 0.035 percentage point increase in diabetes prevalence, on average, controlling for all other variables. Diabetes prevalence was also significantly associated with each of the built environment outlet variables across four of the five regressions. These results are stated previously in section 7.1.3.

### *7.2.4 Spatial Regression Results*

In the spatial regression analysis, all built environment outlets are significant. However, as stated previously, the likelihood ratio test is not significant for any of the models. This indicates that the spatial weight added to these regressions is insignificant. In other words, space is not a significant factor for these variables. The r-square is increased compared to the linear regression analysis, showing that spatial location increases the explained variation between the variables in the analysis. Depending on which built environment factor is being tested, the variation between the variables in these models is explained between 38.7% and 38.9%.

For every one percentage point increase in positive food outlets, diabetes prevalence decreased by 0.307 percentage points. One percent increases in negative food outlets and healthcare facilities were associated with a 0.296 and 0.237 percentage point decreases in diabetes prevalence, respectively. Increases in physical activity facilities and public administration facilities were associated with an 0.224 and 0.676 percentage point decrease in diabetes prevalence, respectively, controlling for all other variables.

Along with the built environment outlets, the neighborhood disadvantage scale was also significantly associated with diabetes prevalence for all five models. For every one-point increase in the neighborhood disadvantage scale, diabetes prevalence increased by between 0.029 and 0.037 percentage points, on average, controlling for all other variables.

## 7.3 Hypothesis 6. Areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes.

### *7.3.1 Descriptive Analyses*

The sixth and final hypothesis states that areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes. The results of the descriptive analysis are shown in Figure 7.14. The first map shows the locations of urban and rural counties in Georgia. As expected, all counties with one major city are considered

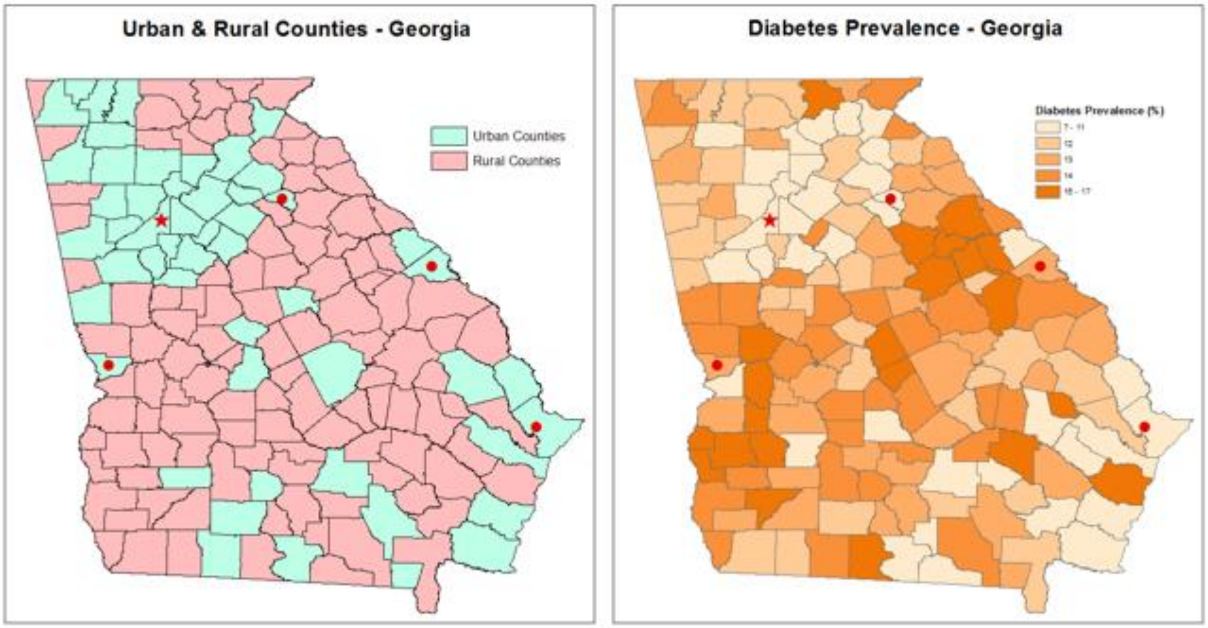



**Figure 7.14. Urban and Rural County Designations, Diabetes Prevalence in Georgia.**

urban, along with the entire metro Atlanta Area, reaching out to Athens in the east and Columbus in the central west. Most of the coastal counties are considered urban, and a few counties along Interstate 75 are also designated as urban. Most of the rest of the central and southern part of Georgia is considered rural. Of the 159 counties in Georgia, 50 are urban and 109 are rural. This corresponds interestingly with the diabetes prevalence map. In general, urban counties have lower rates of diabetes prevalence than rural counties. Most rural counties follow the above-mentioned diabetes belt, located in the southwestern portion of the state, reaching toward the central-eastern part to Augusta.

Unlike most of the other hypotheses, the main independent variable of interest is dichotomous. Thus, it is inappropriate to conduct hot-spot analyses of urban or rural counties. Therefore, I am unable to discuss the results of the built environment in terms of a hot-spot analysis.

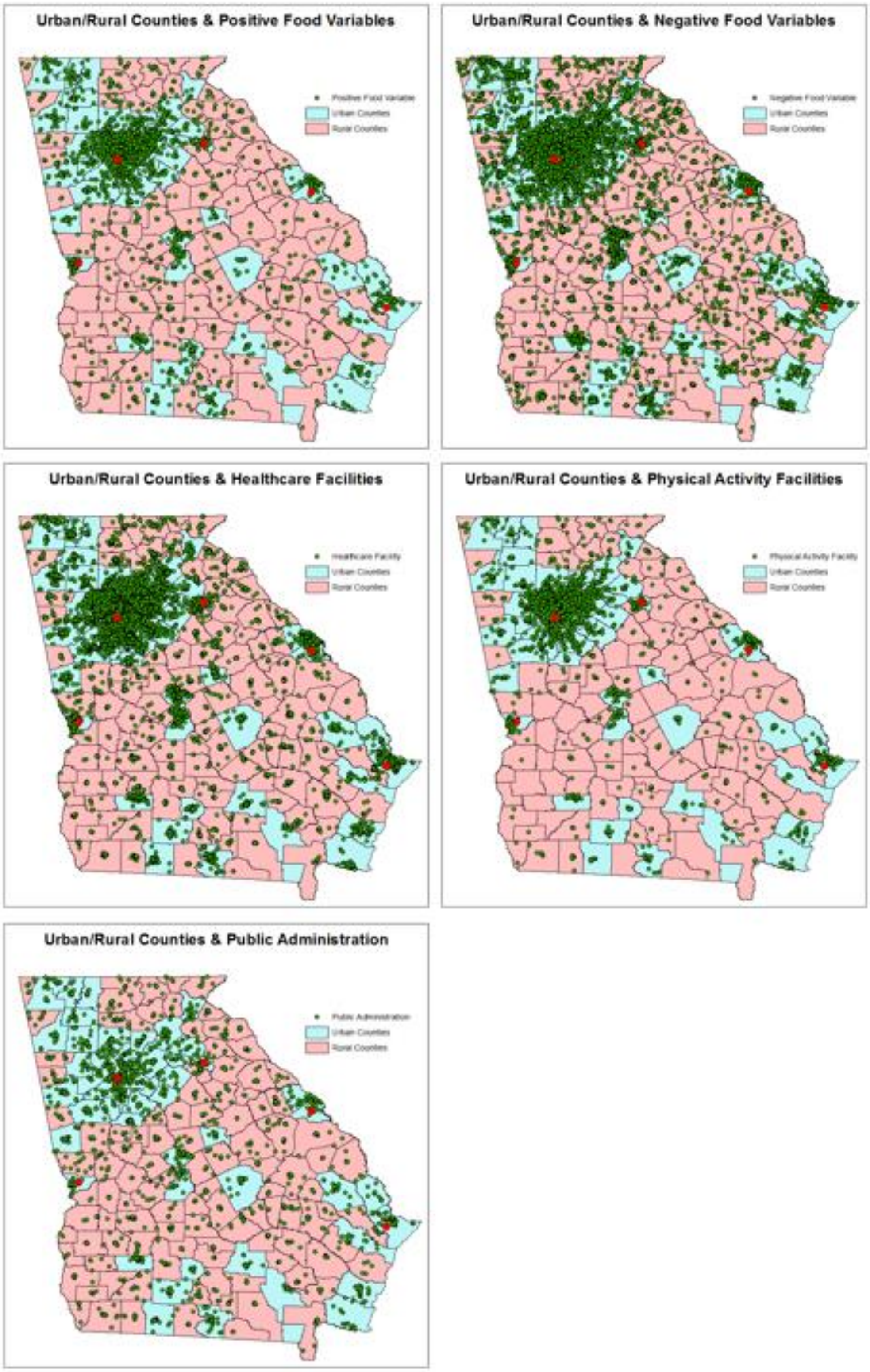



**Figure 7.15. Urban and Rural Counties and Measures of the Built Environment.**

The results of the descriptive maps of urban or rural status are overlaid by the built environment outlets. In the first four variables, the clear majority of built environment outlets are in urban areas. This is clear in terms of the food environments, both positive and negative. While there is a scattering of positive food outlets in rural areas, they are by far more common in urban areas. This is also true for negative food outlets, although they are more common in rural areas than positive food outlets. Healthcare facilities and physical activity facilities are in predominately urban areas as well. While healthcare facilities do exist in small clusters in each county, physical activity facilities often do not. There are very few physical activity facilities located in rural counties. Finally, public administration facilities are distributed evenly throughout the counties in Georgia, regardless of urban or rural designation.

### *7.3.2 GB2SFCA Method Results*

The results of the GB2SFCA method results are shown in Figure 7.16. As a reminder, areas with no purple dots are areas where there is no accessibility to the relevant built environment feature. For example, for physical activity facilities, either the county with no dot has no physical activity facilities at all, or the ones that exist are more than one mile away from the population center in urban counties or ten miles away from the population center in rural counties. This one-mile urban catchment limitation is why many of the counties with no dot at all are in urban areas. For public administration, the same idea exists. Every county has public administration facilities, but in areas with no dot, they are not located within one (or ten) miles of the population center of the county.

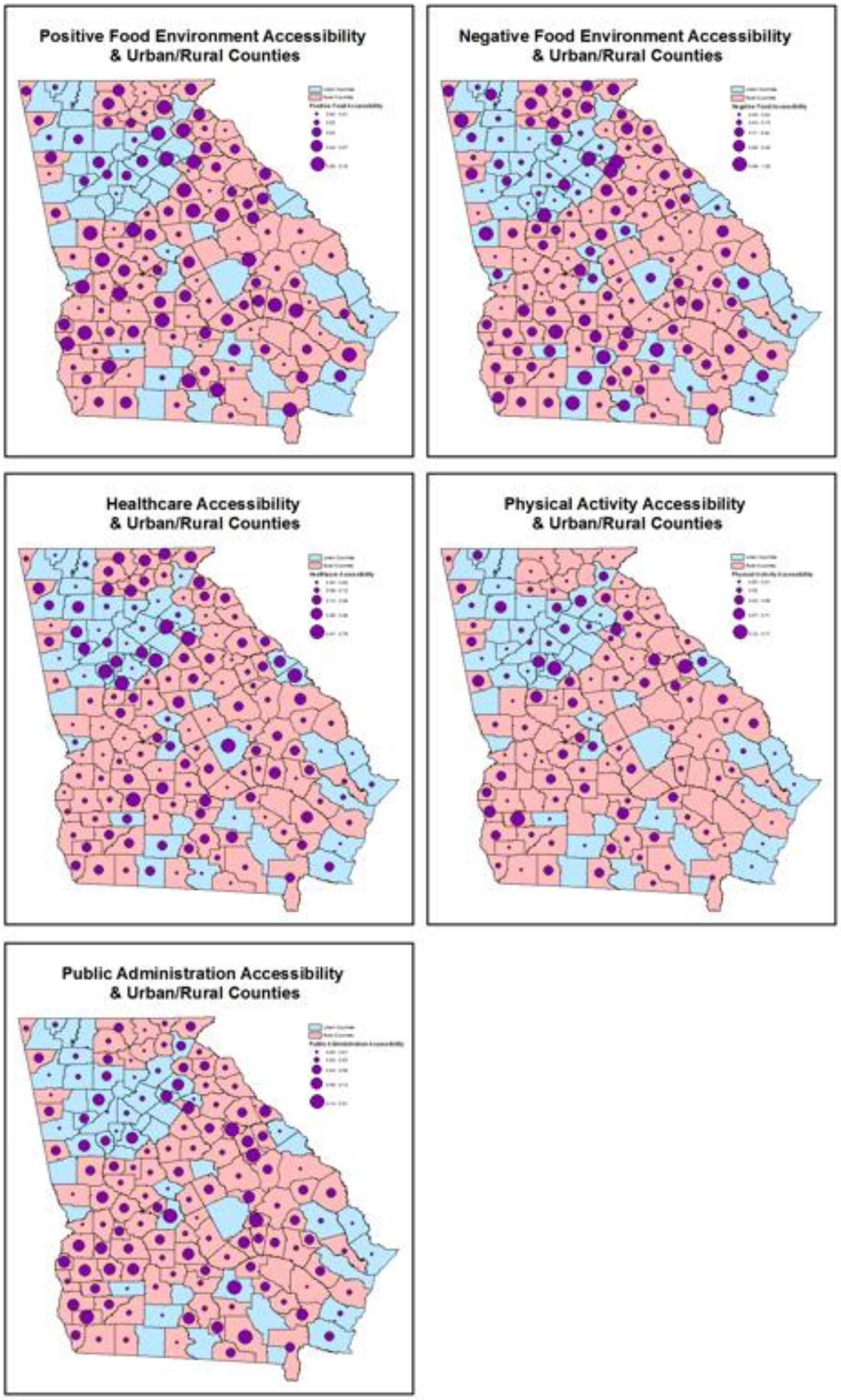



**Figure 7.16. Urban and Rural Counties and Built Environment Outlet Accessibility.**

For positive food outlets, it appears that there is no distinct difference in accessibility for urban versus rural counties. Many counties in rural areas have high accessibility, while some urban areas have no or little accessibility. Negative food environment outlets are a little different. There is higher accessibility to negative food environment outlets in rural areas compared to urban areas. Healthcare facilities are the opposite. In general, there is higher accessibility to healthcare facilities in urban areas compared to rural areas. The same is generally true for physical activity facilities. Except for a couple of counties in southwest Georgia, there is generally low accessibility to physical activity facilities in rural areas compared to urban areas. Finally, public administration facilities, while they number fewer in rural areas, are more accessible to the residents in those counties than for those living in urban areas. Almost exclusively, public administration shows higher accessibility rates in rural areas.

### *7.3.3 Linear Regression Results*

The results of the linear regression analysis are shown in Table 7.1. As stated with the previous regressions, the results of the ANOVA f-test and r-squared are the same as those in hypothesis 2A. Additionally, the four built environment outlets that were significant in the previous hypotheses continue to be so in this model. Urban or rural residence has a significant effect on diabetes prevalence before the built environment variables are introduced. Rural residence is associated with a 0.792 percentage point increase in diabetes prevalence, on average. However, this association disappears completely once every built environment outlet are introduced into the model, indicating that these are mediating factors.

### *7.3.4 Spatial Regression Results*

Finally, the results of the spatial regression analyses are shown in Table 7.2. The results for the spatial regression analysis are very similar to the linear regression analysis. Urban or rural residence is only significantly associated with diabetes prevalence before the introduction of the built environment outlet variables. Rural residence is associated with a 0.710 percentage point increase in diabetes prevalence, on average. This significant association disappears once the built environment variables are introduced. In the built environment models, urban or rural residence is not significantly associated with diabetes prevalence. However, the built environment variables themselves are significantly associated with diabetes prevalence, and are described in detail in section 7.1.4.

In the next section, I will discuss the results of the analyses. Further, I will conduct hypothesis testing to determine whether each hypothesis is substantiated by the data and the analyses. I will then discuss the limitations associated with the variables associated with the analyses as well as the analyses themselves. Next, I will discuss implications of the results in the sociological and public health fields. Finally, I will discuss how these results could be used in future research to reduce disparities in built environment access and diabetes prevalence.

In Chapter 6, I examined the association between sociodemographic factors and the built environment. The results from that chapter show strong support for an existing association between the two. In Chapter 7, I moved deeper into the analysis, by examining whether there was an association between sociodemographic factors, the built environment, and diabetes prevalence. The results in this chapter, for the most part, continue to show strong support for an association between race, income, the built environment facilities, and diabetes prevalence. This outcome was predicted by the application of fundamental causes theory. Fundamental causes theory states that health disparities are persistently associated with social or physical factors despite dramatic changes in diseases, risk factors, and health interventions (Hatzenbuehler, Phelan, & Link, 2013). The results of these chapters show support for fundamental causes theory in that there are indeed racial and income disparities in which built environment facilities are available to residents of particular counties, which is further associated with diabetes prevalence. The results will be discussed in detail in the hypothesis testing section below.

# 8 DISCUSSION

## 8.1 Hypothesis Testing

### *8.1.1 Question 1 - How does neighborhood composition influence the built environment?*

a. 8.1.1.1 Hypothesis 1A – The built environment will decline as African-American presence in a county increases.

For the first hypothesis, I ran descriptive, hot-spot, accessibility, and regression analyses to determine the extent to which the built environment varied based on the racial makeup of the residents who live there. The descriptive results show that there are distinct areas of high Caucasian presence and areas of high African-American presence. Additionally, there are areas of high dissimilarity and areas of low dissimilarity. Interestingly, the areas of low dissimilarity are generally in high African-American areas, while areas of high dissimilarity are in areas that are predominately Caucasian. For the descriptive maps that have race overlaid by built environment outlets, the data shows that positive food outlets, negative food outlets, healthcare facilities, and physical activity facilities are located predominately in areas higher in Caucasian presence, except for the Atlanta area. Overall there are much fewer facilities available in areas of high African-American populations. Therefore, I conclude that there are descriptive differences at the county level in the racial makeup of the residents.

The hot-spot analyses show clusters in both the race and dissimilarity index variables. This justifies the earlier statement that there are differences in racial makeup at the county between Caucasians and African-Americans. There are also significant differences in the dissimilarity index. Not only are there significant differences in race, there are also significant differences in the distribution of race at the county level. That the hot-spots are generally in the same vicinity (e.g. southwest race hot-spot, and northern race cold spot) indicate that there is considerable variation in racial makeup at the county level. These results corroborate the earlier claim that there are differences at the county level in the racial makeup and the dissimilarity index of residents.

To determine whether the hot-spots showed variation in the built environment, I placed the built environment outlets over the hot-spot analyses. The results show unequivocally that areas of high African-American concentration have lower levels of built environment outlets available to the residents. This is evident in the hot-spot analyses. There are some high African-American clusters that have no positive food environment outlets or physical activity variables at all. However, every area of high Caucasian clustering has at least one of these two variables within their county. These results continue to help bolster the claim that there is a difference in racial makeup of residents *and* that the built environment does vary in areas of high African-American clustering and Caucasian clustering.

The next analysis used the Gaussian-Based Two-Step Floating Catchment Area method to determine accessibility. Accessibility was calculated as the catchment area around the built environment outlet of interest, and the catchment area around the population center. The catchment area for urban areas was one mile, while for rural areas, it was ten miles. Areas with high accessibility were designated as larger dots, while areas of lower accessibility were labeled as smaller dots. Areas with no dots at all had no accessibility to the built environment outlet. The results of the built environment outlet accessibility show that for the variables of healthcare facilities, accessibility was quite low in predominately African-American areas. Interestingly, the opposite showed true for the physical activity facilities. Areas of high African-American population had higher accessibility to physical activity areas, even though they may be few. This is likely due to the rurality of the area and the resultant larger catchment area size. The same can't be said for healthcare facilities, as there are few in predominately African-American areas and they are not readily accessible to the residents. These results continue to support the first hypothesis.

The next two analyses I conducted were the regression analyses. First was the linear regression, to determine the extent to which the independent variables influenced the dependent variable, without adding in a spatial factor. For this analysis, the results show overwhelming support for the hypothesis being tested. For nearly every built environment outlet, there was significant change when regressed upon the percentage of African-Americans living within a county. All built environment factors increased as African-American presence increased. However, this is probably tempered by rural and urban factors. Urban areas are likely to have more built environment facilities, and African-American presence tends to increase in urban areas.

The second regression analysis added a spatial weight. This weight helped group variables based on their location by using nearby county statistics as weights. For the most part, the significance remained the same, and in the same direction, although for the spatial regression, positive food environment was significantly associated with the percentage of African-Americans living in a county. Again, increases in African-American population were associated with increases in all built environment outlets, positive or negative.

Overall, the results of testing the first hypothesis show unanimous support of the rejection of the null hypothesis. All analyses show that there are significant differences in the racial makeup of residents who live in particular counties. There are also significant differences in the built environment, both in the number of facilities available as well as the accessibility of these facilities to the residents in each county. In conclusion, for hypothesis one, that the built environment will decline as African-American presence in a county increases, I must reject the null hypothesis and conclude that there are significant differences in racial makeup and built environment availability and accessibility at the county level for residents who live in Georgia. However, the built environment tends to be more accessible (and therefore improves) in areas of higher African-American population.

#### 8.1.1.2 Hypothesis 1B - The built environment will improve as the neighborhood disadvantage scale decreases at the county level.

The second hypothesis tested states that the built environment will improve as the neighborhood disadvantage scale decreases at the county level. Much like the racially-based hypothesis above, it implies that income will vary significantly from county to county, and that the variation will be associated with the built environment outlets available to the residents who live there. To test this hypothesis, I conducted the same analyses as above, descriptive analyses, hot-spot analyses, 2SFCA method analyses, and linear and spatial regression analyses.

The first analyses were descriptive analyses of median household income and neighborhood disadvantage index. The results show that there were distinct differences in both median household income and the neighborhood disadvantage index. For median household income, the higher income areas were essentially located in and around Atlanta, as well as the coastal counties and the suburban areas of the other major cities in Georgia. The lowest income areas are in the swath of counties earlier designated as Georgia's diabetes belt. These are the counties ranging from southwest Georgia through the central-eastern section. The neighborhood disadvantage index matches up nicely with the income map. As a reminder, the neighborhood disadvantage index measures the unemployment rate of a county, the education level, and income below $30,000 a year. The areas with the lowest neighborhood disadvantage are the areas around Atlanta and the coastal counties, in general. The areas of highest disadvantage follow the same swath as the lowest income counties. These results show support for the hypothesis by showing that there are significant differences in median household income and in neighborhood disadvantage scores.

The second analyses build upon the first by adding built environment outlets to the income distribution maps. The results of these are even starker than those for race above. The built environment outlets are almost all in areas of higher income. The lowest income areas have hardly any built environment outlets at all. This is especially true for positive food outlets, healthcare facilities, and physical activity facilities, arguably the most important variables for good health. The clear majority of all built environment outlets are in the Atlanta area, which is also the highest income section of Georgia. These results help support the hypothesis.

The next analyses are the hot-spot analyses. These help show definitively that there are significant differences in income in areas throughout Georgia. The income hot-spots are in and around Atlanta and the Savannah areas. The neighborhood disadvantage cold spots (indicating low disadvantage) are in the same areas. The cold spots for income are in the same areas as the hot-spots for neighborhood disadvantage. The next part of these analyses was overlaying the built environment outlets over the hot-spot analyses. The results of these show unequivocal evidence that built environment outlets are in areas of high income and low neighborhood disadvantage. The areas of lowest income and highest disadvantage have hardly any built environment outlets available to the residents of those counties. These results corroborate the previous data and support the hypothesis being tested.

The GB2SFCA method results are next. Interestingly, although built environment outlets are plentiful in higher income areas and lesser in lower income, there does not seem to be an association between accessibility to built environment outlets and income. The only exception is healthcare facilities, which are more accessible in higher income areas. This, so far, is the only analysis that does not fully support the hypothesis.

The next two analyses are the linear and spatial regression analyses. While the 2SFCA method analyses were inconclusive, the linear regression analyses were perfectly clear in terms of neighborhood disadvantage. The neighborhood disadvantage variable was significantly associated with all the built environment outlets, except for the positive food environment. These results show that for every increase in the neighborhood disadvantage scale, there was a significant decrease in the number of negative food environment outlets, healthcare facilities, physical activity facilities, and public administration facilities available to the residents in the area. The spatial regression analysis adds the spatial weight to the model. Increases in neighborhood disadvantage scale are associated with decreases in the built environment outlets that are available in these areas. These results support the hypothesis.

Overall, I must conclude that the hypothesis that the built environment will improve as the neighborhood disadvantage index decreases at the county level. Although accessibility did not appear to be particularly associated with income at the county level, the other results showed that there were significant differences in income between counties. Further, these differences were associated with differences in availability of each built environment outlet. Therefore, I must reject the null hypothesis and conclude that there are significant differences in the neighborhood disadvantage scale which lead to significant differences in the built environment.

#### 8.1.1.3 Hypothesis 1C - The built environment will be better in urban areas and worse in rural areas at the county level.

To test the third hypothesis, that the built environment will vary based on the geographic density of the areas where people live, I conducted the same analyses as above. I began by conducting spatial descriptive statistics. To do this, I presented Georgia on a map and showed where the urban and rural counties are. Additionally, I presented a map showing the population density of each county in Georgia. The results of these show that urban areas are around all the major cities in Georgia, but most prominently in Atlanta and the metro region. Metro Atlanta only officially includes nine counties, but as the maps show, most of the northern region is considered urban and has the highest rates of population density in the state.

The next descriptive maps have the variable of population density overlaid by the built environment outlets. As with the previous two hypotheses, there is an association between where built environment outlets are located and where the most population dense areas are. Every built environment outlet, with perhaps the exception of public administration variables, are positively associated with increased levels of population density. This is particularly true for both positive and negative food environment outlets, as well as physical activity variables. There are quite a few counties that do not have any physical activity facilities. Keep in mind that the variable of physical activity facilities includes state parks and playgrounds, areas that are publicly owned. There are also a couple of counties with no positive food outlets at all, such as Quitman County. These results show that there are distinct differences in the population size of each county, and that these differences are associated with the built environment that is available to the residents of each county.

The next analysis was the hot-spot analysis for population density. I could not conduct a hot-spot analysis on urban or rural county, as hot-spots do not work for dichotomous variables. The results for these were straightforward. The only population cluster in Georgia is in Atlanta and the metro area. Again, the built environment outlets were overlaid on these maps. They show strong evidence that the clear majority of built environment outlets are in and around Atlanta. The rest of the counties have a smattering of each variable, and there are some clusters around the other major cities, but the built environment outlet distribution around Atlanta is such that it can be difficult to see the results of the cluster analysis underneath. The results of these provide more evidence that the hypothesis has credence, and that the built environment does vary based on geographic density.

The results of the GB2SFCA method analyses are incredibly interesting. Although each different built environment outlet is much more available in and around Atlanta, there are not necessarily more accessible. In fact, rural areas are much more likely to have greater accessibility to most of the built environment outlets than urban areas. The exception is for healthcare facilities. In general, they are much more accessible in urban areas. The most likely explanation for this is the measurement used to determine accessibility. As urban areas were given a one-mile catchment area and rural areas were given a ten-mile catchment area, consistent with the USDA food atlas, rural areas have ten times more space available to have a built environment outlet considered accessible to them. Overall, this is the first analysis that does not provide unanimous support for the hypothesis being tested.

The final two analyses used to test this hypothesis were the linear and the spatial regression models. They both show support for the hypothesis that the built environment varies based on the geographic density of where one lives. For the linear regression, every built environment outlet was significantly associated with urban or rural residence. Overall, areas with fewer people had significantly fewer built environment outlets available to the residents of those counties. Even after adding a spatial weight to the model, the spatial regression shows the same results. Every built environment outlet was scarcer in rural areas. These two analyses provide unequivocal support for the hypothesis.

Based on the results of the analyses above, I must reject the null hypothesis and conclude that there are significant differences in the built environment based on the urban or rural designation of a county. The accessibility measure does not absolutely support this, but every other analysis does. However, even the accessibility measure does show that some built environment outlets are associated with urban or rural status. Every other analysis shows no doubt that there is an association between the variables. Therefore, I conclude that the built environment varies significantly based on the geographic density of where people live, and the hypothesis is sustained.

### *8.1.2 Question 2 - How do neighborhood composition and built environment together influence diabetes prevalence?*

The next section of the dissertation builds upon the first question and asks how neighborhood composition and built environment, together, influence diabetes prevalence. To answer this question, I proposed three hypotheses. These, to some extent, mirror the questions asked in the first question. The first hypothesis in this section (hypothesis 4 overall) states that areas of higher minority racial residential segregation will have lower access to healthful facilities and a higher prevalence of diabetes. Hypothesis five states that areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes. Finally, hypothesis six states that areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes. These hypotheses will help answer the question of the extent to which neighborhood composition and built environment together influence diabetes prevalence.

#### 8.1.2.1 Hypothesis 2A - Areas of higher African-American presence will have lower access to healthful facilities and a higher prevalence of diabetes.

This hypothesis will examine racial residential segregation and its association with built environment outlets, and to its association with diabetes prevalence at the county level. To test this hypothesis, I conducted several analyses. First, I conducted descriptive spatial statistics. These maps showed dissimilarity index at the county level, along with diabetes prevalence at the same level. The results show that there are distinct differences in dissimilarity index as well as for diabetes prevalence throughout Georgia. The areas of highest dissimilarity are mostly in the northern areas of Georgia, while the lowest areas of dissimilarity are mostly in the central section of Georgia. Interestingly, the diabetes prevalence map shows a relationship with dissimilarity index. Areas of high dissimilarity appear to be associated with a lower prevalence of diabetes, while areas of lower dissimilarity are associated with higher prevalence of diabetes. The next descriptive maps show dissimilarity index overlaid by the built environment outlets. Overall, there was not a strong association between the two variables, except for negative food environment outlets. In general, negative food environment outlets are associated with areas of higher dissimilarity. The next maps show diabetes prevalence and built environment outlets. Interestingly, every built environment outlet, except for public administration, was more likely to be in areas of lower diabetes prevalence. These include both the positive and negative built environment outlets. Overall, the descriptive results do not show distinct support for the hypothesis, but they do not explicitly reject it either.

The next analyses are the hot-spot analyses for dissimilarity index and diabetes prevalence. As this is the first hypothesis in the second section, all analyses regarding diabetes prevalence were conducted in this section, but are applicable through the rest of the hypotheses. The hot-spots for dissimilarity index show that the areas of highest dissimilarity are in the northern section of Georgia, while areas of lowest dissimilarity are in the central section of Georgia. The diabetes prevalence hot-spot results are similar, but opposite to the dissimilarity index scores. These were mentioned in detail in the previous section. The hot-spot analyses for dissimilarity index provide support for the hypothesis, in that they are more plentiful in areas of higher dissimilarity and fewer in areas of lower dissimilarity. This provides support for the idea that one, racial segregation exists in Georgia, and two, that this segregation is associated with increased built environment outlets. Therefore, these results provide evidence to support the hypothesis. The next analyses pitted diabetes prevalence with the built environment outlets. Again, all built environment outlets, except public administration, are associated with areas are lower diabetes prevalence. This corroborates the earlier descriptive statistics regarding diabetes prevalence and built environment outlets, and provides greater evidence to support the hypothesis.

The next analyses conducted examined accessibility for both dissimilarity index and diabetes prevalence. For the dissimilarity index, only greater access to healthcare facilities were distinctly associated with areas of higher dissimilarity. The other variables did not indisputable evidence of an association. For diabetes, the results are essentially the same. Only healthcare facilities show a direct association between accessibility to these features and diabetes prevalence. These results do not directly provide evidence to support the hypothesis.

As the results so far for the testing of this hypothesis have been ambiguous, the determining factor that may deem this hypothesis sustained lie in the regression analyses. In the linear regression analysis, there is a significant negative association with nearly every built environment facility (except for the positive food environment) and diabetes prevalence. As each built environment outlet increases, diabetes prevalence decreases. This is corroborated with the spatial analyses, which take location into account. The results for the spatial analysis similar to the linear regression, but in this case, every built environment outlet is significantly negatively associated with diabetes prevalence. These results provide strong evidence that the built environment is significantly associated with diabetes prevalence.

Overall, this hypothesis states that areas of higher minority racial residential segregation will have lower access to healthful facilities and a higher prevalence of diabetes. The results show that there is an association between the percentage of African-Americans in a county and built environment outlet availability, although not necessarily accessibility. Additionally, the analyses show that the number of healthful facilities in an area is significantly associated with diabetes prevalence. Because this hypothesis stresses access and not availability, I must fail to reject the null hypothesis and conclude that there are no significant differences in racial residential segregation and *access* to facilities, but that there are significant differences in built environment facilities *available* to residents and diabetes prevalence.

#### 8.1.2.2 Hypothesis 2B - Areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes.

Hypothesis five examines neighborhood disadvantage, the built environment, and diabetes prevalence. This testing seeks to validate the hypothesis that areas that are poorer will have lower access to healthful facilities and a higher prevalence of diabetes. To conduct the hypothesis testing, I first conducted descriptive statistics of neighborhood disadvantage index and diabetes prevalence. Then, I conducted hot-spot analyses and compared those to the built environment outlets to see if there were associations between the two. Next, I conducted a 2SCFA method analysis to determine accessibility. Finally, I conducted linear and spatial regressions to examine the relationships between the variables. The results of these analyses will allow me to determine whether I can reject or fail to reject the null hypothesis of no association.

For the descriptive statistics, I mapped neighborhood disadvantage index and diabetes prevalence, and then overlaid the built environment outlets on them to examine the association between the variables. The results show that there is quite a difference by county in neighborhood disadvantage index, with the northern and coastal counties of Georgia having lower disadvantage, while the central and southern counties have the highest levels of disadvantage. This is well correlated with diabetes prevalence. Areas of lower disadvantage are associated with lower diabetes prevalence, and areas of higher disadvantage are associated with higher levels of diabetes prevalence. When overlaying the built environment outlets over the neighborhood disadvantage index, there is a negative association. Areas of lowest disadvantage are associated with greater availability of built environment outlets. This is especially noticeable for positive food outlets and physical activity facilities, but is also seen for healthcare facilities. Residents of the highest disadvantage have better availability of negative food outlets than of the other two, combined. This matches up with the maps of diabetes prevalence and built environment outlets. Areas of lower diabetes prevalence have greater availability of the positive food outlets, and areas of higher prevalence have lesser availability of positive variables and greater availability to negative food outlets. These results support the hypothesis that areas that are poorer have lower access to healthful facilities, and may be associated with a higher prevalence of diabetes.

The next analyses are the hot-spot analyses. The results show that the hot-spot areas are in the southwestern corner of Georgia and in the few counties between Athens and Augusta. The cold spots are most of Atlanta and the metro area, and the Savannah area. These analyses, overlaid by the built environment outlets, provides further evidence of the statements made in the previous analysis. The cold spot clusters (areas of lowest disadvantage) are much more likely to have positive variables such as positive food outlets, healthcare facilities, and physical activity facilities. They are also more likely to have negative food outlets, but these are also apparent in the hot-spot areas as well. These results provide further support for the hypothesis, beyond simple visual descriptive statistics.

After the hot-spot analyses are the accessibility analyses. The results of these show that negative food outlets are more accessible in higher disadvantage areas, while healthcare facilities have lower accessibility in these counties. These show that not only are healthcare facilities few in disadvantaged counties, they are also of lower accessibility to the residents who live there. Physical activity facilities and positive food environment outlets do not appear to have a strong accessibility association with neighborhood disadvantage. Even with the lack of association for two of the variables, I still must state that the accessibility analysis provides further support that the built environment does vary based on the neighborhood disadvantage index score of each county.

The final analyses run to test this hypothesis are in the forms of a linear regression and a spatial regression. The results of these provide support to the idea that differences in the built environment significantly affect diabetes prevalence. For the linear regression, four of the five built environment outlets are significantly negatively associated with diabetes prevalence. Therefore, as the availability of these variables increases in the built environment, diabetes prevalence declines. Neighborhood disadvantage is also significant, indicating that counties that have higher neighborhood disadvantage index scores are associated with higher rates of diabetes prevalence. This is corroborated in the spatial regression. For the spatial regression, every built environment outlet is negatively associated with diabetes prevalence. Additionally, once the spatial weight was added, neighborhood disadvantage continued to be significant for every model. This means that the neighborhood disadvantage index significantly affects diabetes prevalence in a county, just as the number of each built environment outlet does. Therefore, this analysis provides support for the second half of the hypothesis, that differences in the built environment affect diabetes prevalence.

With the results of the earlier analyses, I can conclude that differences in neighborhood disadvantage is associated with differences in the built environment, and these analyses show that differences in the built environment affect diabetes prevalence. Therefore, the hypothesis is sustained. I reject the null hypothesis of no association and conclude that there are significant differences in neighborhood disadvantage, the built environment, and diabetes prevalence in counties throughout Georgia.

#### 8.1.2.3 Hypothesis 2C - Areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes.

The final hypothesis tested states that areas that are more rural will have lower access to healthful facilities, which will be associated with a higher prevalence of diabetes. To test this hypothesis, I used the same analyses I have used in the previous five hypotheses, except for the hot-spot analyses. As urban or rural status is a dichotomous variable, hot-spot analyses will not work properly.

The first analyses are the descriptive spatial analyses. These show the urban and rural counties overlaid by the built environment outlets. These are perhaps the most blatant in terms of where built environment outlets are located. Almost absolutely, all the built environment outlets are in urban areas. There are a few in rural areas, but the clear majority are in urban areas. These results provide support for the hypothesis, in that urban areas are distinctly different in terms of the built environment facilities available to the residents who live there.

The next results are from the 2SFCA method. Negative food environment outlets are much more accessible in rural areas than urban areas. On the contrary, healthcare facilities and physical activity facilities are much more accessible in urban areas. These results further provide support for the differences in accessibility to built environment outlets due to geographic density of counties in Georgia.

The final results come from the linear and spatial regression analyses. In the linear regression, the same four built environment facilities are significant. However, urban or rural status alone, for the most part, does not influence diabetes prevalence. These results are sustained in the spatial regressions. Urban or rural status is only significantly associated with diabetes prevalence before the built environment factors are introduced, meaning that there is no significant association between urban or rural residence, the built environment, and diabetes prevalence.

In general, the evidence supports the validity of the hypothesis being tested. While there is some ambiguity with the regression models, there are some significant variables, and all the other analyses show a significant association with urban and rural county status and built environment outlets, and a subsequent association with diabetes prevalence, although it is weaker than some of the previous hypotheses. Therefore, I reject the null hypothesis of no association and conclude that there are significant differences between urban and rural counties and the built environment outlets there to serve the residents of these counties, which is also significantly associated with the rates of diabetes prevalence in the same.

Overall, five of the six hypotheses were sustained. These results show unequivocally that certain neighborhood factors, such as race, income, and geographic density, absolutely affect the supermarkets, grocery stores, fast food restaurants, convenience stores, restaurants, healthcare facilities, gyms, parks, police stations, and fire stations available to the residents of particular counties. Further, these associations are further associated with diabetes prevalence. Areas that are lower in African-American population, or are poorer, or are more rural, are more likely to have fewer of these facilities available to them. They are also more likely to have higher rates of diabetes.

The results of the analyses show strong support for fundamental causes theory. Fundamental causes theory states that social factors are fundamental causes that influence health. As this analysis has shown, the social factors of income, education, and public welfare assistance (in the form of the neighborhood disadvantage index), race, and population density are associated with diabetes prevalence. In areas of higher African-American population, diabetes prevalence is higher. In areas of lower education and income, and higher rates of public welfare assistance, diabetes prevalence rates are higher. Finally, areas that are more rural have some spatial evidence that diabetes risk is higher in those areas.

In this analysis, the built environment serves as a mechanism by which social factors influence health. The built environment facilities, such as supermarkets and grocery stores, convenience stores and fast food restaurants, healthcare facilities, parks and gyms, and police or fire stations, that are available to residents can influence residents' health. Research has shown that residents who have greater access to supermarkets and physical activity facilities, and limited access to convenience stores and fast food restaurants tend to have healthier diets and lower levels of obesity (Grier & Kumanyika, 2008; Harris, Pomeranz, Lobstein, & Brownell, 2009; Institute of Medicine, 2006; Lake et al., 2006; Larson et al., 2009). The results from this analysis corroborate these findings. Areas with greater access to positive built environment features such as supermarkets, healthcare facilities, and physical activity facilities, and lesser access to negative built environment features such as fast food restaurants and convenience stores had lower levels of diabetes prevalence.

Fundamental causes theory is based on the tenet that health disparities are caused primarily by social factors. Race is a social factor that can influence health. In the United States, African-Americans have higher mortality rates than any other group for chronic diseases, and are up to 100% more likely to have diabetes than Caucasians (Frist, 2005; Hummer, Rogers, Nam, & LeClere, 1999; Signorello, Schlundt, Cohen, Steinwandel, Buchowski, McLaughlin, & Blot, 2007; Shulz et al., 2002; Zenk et al., 2005a). Again, these analyses support prior research. The results of this study show that areas of higher African-American population have higher rates of diabetes prevalence. Income, education, and other social factors follow the same pattern. Diabetes prevalence tends to be inversely associated with income (Frohlich, Ross, & Richmond, 2006). The results presented here show that areas of higher socioeconomic disadvantage were also areas of higher diabetes prevalence.

For the social factors of race, neighborhood disadvantage, and to some extent, population density, fundamental causes theory explains why these factors influence health. Adding the built environment to the models helps show a tangible way by which social factors influence the built environment, which influences health above and beyond social factors alone.

## 8.2 Limitations

There are a several limitations associated with a study this large. The first involves the data itself. In this study, all analyses were conducted at the county level. This was because diabetes prevalence, indeed any kind of chronic health data, is only available at the county level or higher. Usually, health data is only reliable at the state level, but due to small-area estimation, I could conduct analyses at the county level. This is a limitation because counties can differ dramatically from one end to the other. Take Fulton County, for example. This is the seat for the city of Atlanta, a city that has maintained its dubious distinction of being the most unequal city in the country for 2014-2015 (Bertrand, 2015). Income for the top five percent is more than eleven times more than for the lowest twenty percent. Yet in this study, all residents of Fulton County are lumped together. This is perhaps the biggest limitation in this study. Secondly, the data is cross-sectional. It is only a snapshot in time. It would be interesting to see what the data looks like over time, as diabetes prevalence increases throughout the country. Finally, because Georgia is one of the more diverse states in the country, it would be difficult to generalize the information to other counties or areas. Regional differences, in diabetes prevalence, in racial makeup, in geographic and socioeconomic distributions, would make it difficult to compare Georgia's results to Minnesota, for example.

The second group of limitations addresses diabetes. In this study, type 1 and type 2 diabetes are not specifically distinguished. In the original survey from which the data was gathered, the question simply asked, "Have you ever been told by a doctor that you have diabetes?" Further, diabetes is self-reported. However, this limitation is small, as research shows that 95% of diabetes cases in adults is type 2 diabetes.

Finally, a third limitation is that, although most of the hypotheses were justified, there could be alternate explanations for these phenomena. Other social issues, such as crime, could affect diet, physical activity, and overall health. If one does not feel safe in their neighborhood, they are unlikely to take a brisk stroll after dinner. This is a legitimate concern and likely a plausible explanation for an increase in diabetes prevalence in some counties. However, I decided not to include crime in my analyses, as all the built environment outlets were physical locations, and two of the three main sociodemographic variables (race, income, and geographic density) were index scores from published, valid measures. Finally, crime rates were relatively un-clustered (see Appendix B), and at the county level, may not have gleaned the information that a more in-depth analysis would. Overall, I felt that crime rates fell outside the scope of this study, and would be of better use in a study where it would be the main focal point.

### 8.2 Implications and Future Research

The results of this dissertation are incredibly suggestive of the potential for continued research into the intersectionality between sociology and public health. The sociological determinants of health have only been recently studied in detail, and the implications of this research help determine the importance of considering sociological factors in public health research.

Sociological factors can have an immense impact on one's health. Factors such as neighborhood racial makeup, median household income, education level, and unemployment rates affect neighborhood composition. Neighborhood composition can consist of features such as population density, neighborhood disadvantage, and racial residential segregation. These factors, along with the sociological factors above, influence what type of health-related facilities are available in the area. Service facilities such as supermarkets, grocery stores, fast food restaurants, convenience stores, healthcare facilities, physical activity facilities, and public administration facilities are often located differentially based on the sociological and neighborhood composition features of an area. This in turn can affect health, specifically the likelihood of developing a chronic disease, such as hypertension, heart disease, or diabetes. This dissertation focused on diabetes prevalence, but it is likely that similar results could be found substituting diabetes with another major chronic disease.

Another important implication of this work is the ease by which the theory of fundamental causes could be applied directly to the intersectionality between sociology and public health. Of course, the basic premise behind the theory of fundamental causes is that there is a distinct link between socioeconomic and demographic factors that affect health. However, few studies have provided explicit evidence in support of this theory to this extent. My research shows definite evidence that sociodemographic factors influence the built environment, which influence diabetes evidence. This was not true for every hypothesis tested, but for the clear majority of them. Further, this research expanded upon the theory of fundamental causes by adding factors of the physical or built environment as a segue between socioeconomic status and health. Neighborhood socioeconomic status affects which facilities are available to residents who live there, which in turn affect health.

The implications above help pave the way for future research considerations. There are several research projects that would expound on the results learned here. Perhaps the most apparent quality of this dissertation is the fact that it was conducted on a relatively large scale. Future research can focus on a much smaller area to get an in-depth look at the exact ways socioeconomic status, sociodemographic variables, and the built environment affect health. It would be interesting to conduct this same research at the neighborhood or block group level, using neighborhood-level built environment assessments along with interviews with local residents to discover their health issues, along with the health-related facilities they use in an area. Further, future research can focus on the idea of determining catchment areas for built environment facilities that are not subject to invisible county lines. This would provide a much more accurate, albeit less generalizable, picture of the relationship between these factors.

Finally, one of the major characteristics of this study that was brought out in full force is the idea of availability versus accessibility. It was interesting to see that while there may be several facilities, for example, healthcare facilities, *available* to the residents of a county, they weren't exactly considered *accessible* to the residents. This was especially apparent in rural counties, where the catchment area was ten times the size of the catchments in urban areas. This could drive future research in the fields of public policy and land development. An in-depth four-layered study examining good accessibility and good availability, good accessibility and poor availability, poor accessibility and good availability, and poor accessibility and poor availability would be very informative in research into urban and rural planning.

# 9 CONCLUSION

In this study, I sought to determine the answers to two major questions. First, how does neighborhood composition affect the built environment? And second, how does neighborhood composition and built environment combined affect diabetes prevalence. To find these answers, I conducted multiple analyses, including descriptive analyses, hot-spot analyses, the two-step floating catchment area method analyses, and linear and spatial regression analyses. The results show that both questions above were answered sufficiently. The first three hypotheses determined the relationship between race, income, and population density with where built environment facilities were located in counties throughout Georgia. All three hypotheses were sustained, indicating that there is indeed a relationship between the three sociological variables and the built environment. The second three hypotheses examined the association between racial residential segregation, neighborhood disadvantage, and rural and urban location and diabetes prevalence. Two of the three hypotheses were sustained, indicating that there is an association between neighborhood disadvantage, urban or rural residence, built environment facilities, and diabetes prevalence.

Racial and socioeconomic disparities exist in diabetes prevalence. Disparities also exist within the built environment. The purpose of this dissertation was to contribute to fundamental causes theory by helping to explain differences in access to healthful facilities and the health conditions that can result as a consequence. The main assertion of fundamental causes theory is that social conditions are fundamental causes of health. This dissertation provides support to this idea, and builds upon it by establishing a relationship between social factors, the built environment, and health factors (in this case, diabetes prevalence).

Another major tenet of fundamental causes theory is that, unfortunately, health disparities will never disappear. If the significant factors found in my research were to be eliminated, rendering all built environments and social factors equal, other factors would develop to take their place. In the meantime, however, these differences in sociological factors, built environment facilities, and diabetes prevalence do exist. Therefore, attention from policy makers, land developers, and community residents is critical to allow improved access to disadvantaged counties to improve the quality of life for all residents throughout Georgia.

# REFERENCES


Adler, N., Boyce, T., Chesney, M., Cohen, S., Folkman, S., Kahn, R., & Syme, S. (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist*, *49*(1), 15.

America's Health Rankings. (2015). Retrieved December 29, 2016 from http://www.americashealthrankings.org/explore/2015-annual-report/measure/Overall/state/GA.

Anderson, L. M., St. Charles, J., Fullilove, M. T., Scrimshaw, S. C., Fielding, J. E., & Normand, J. (2003). Providing affordable family housing and reducing residential segregation by income. *American Journal of Preventive Medicine*, *24*(3), 47–67.

Anselin, Luc. (1995) Local Indicators of Spatial Association—LISA. *Geographical Analysis* 27(2): 93–115.

Bachmann MO, Eachus J, Hopper CD, et al. (2003). Socio-economic inequalities in diabetes complications, control, attitudes and health service use: A cross-sectional study. *Diabet Med, 20,* 921–9.

Baicker, K., Chandra, A., Skinner, J. S., & Wennberg, J. E. (2004). Who you are and where you live: How race and geography affect the treatment of Medicare beneficiaries. *Health Affairs, 33,* 33-44.

Baicker, K., Chandra, A., & Skinner, J. (2005). Geographic variation in health care and the problem of measuring racial disparities. *Perspectives in Biology and Medicine*, *48*(1), S42-S53.

Barker, L. E., Kirtland, K. A., Gregg, E. W., Geiss, L. S., & Thompson, T. J. (2011). Geographic distribution of diagnosed diabetes in the US: A diabetes belt. *American Journal of Preventive Medicine*, *40*(4), 434-439.

Behavioral Risk Factor Surveillance System. (2014) Retrieved December 15, 2014 from http://www.cdc.gov/brfss/data_documentation/PDF/UserguideJune2013.pdf.

Bernard, P., Charafeddine, R., Frohlich, K. L., Daniel, M., Kestens, Y., & Potvin, L. (2007). Health inequalities and place: a theoretical conception of neighbourhood. *Social Science & Medicine*, *65*(9), 1839-1852.

Bernstein, K. T., Galea, S., Ahern, J., Tracy, M., & Vlahov, D. (2007). The built environment and alcohol consumption in urban neighborhoods. *Drug and Alcohol Dependence, 91*(2), 244-252.

Bertrand, N. (2015). Atlanta is the most unequal city in America – Here's Why. Retrieved January 9, 2017 from http://www.businessinsider.com/atlanta-is-the-most-unequal-city-in-america--heres-why-2015-3.

Block JP, Scribner RA, DeSalvo KB. (2004). Fast food, race/ethnicity, and income. *Am J Prev Med, 27,* 211–7.

Booth, G. L., Hux, J. E., Fang, J., & Chan, B. T. (2005). Time trends and geographic disparities in acute complications of diabetes in Ontario, Canada. *Diabetes Care*, *28*(5), 1045-1050.

Bosworth HB, Dudley T, Olsen MK, et al. (2006). Racial differences in blood pressure control: Potential explanatory factors. *Am J Med, 119(70),* e9–15.

Bowser, B. P. (2007). *The Black middle class: Social mobility--and vulnerability*. Boulder: Lynne Rienner.

Brown, A. F., Gregg, E. W., Stevens, M. R., Karter, A. J., Weinberger, M., Safford, M. M., ... & Beckles, G. L. (2005). Race, ethnicity, socioeconomic position, and quality of care for adults with diabetes enrolled in managed care the Translating Research into Action for Diabetes (TRIAD) study. *Diabetes Care*, *28*(12), 2864-2870.

Centers for Disease Control and Prevention. (2014a). *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2014*. Atlanta, GA: U.S. Department of Health and Human Services.

Centers for Disease Control and Prevention. (2014b). *Long-term trends in diabetes, 2014*. Atlanta, GA: U.S. Department of Health and Human Services.

Christian, H., Giles-Corti, B., Knuiman, M., Timperio, A., & Foster, S. (2011). The influence of the built environment, social environment and health behaviors on body mass index: Results from RESIDE. *Preventive Medicine*, *53*(1), 57-60.

Chuang, Y.C., Ennett, S.T., Bauman, K.E., Foshee, V.A. (2005). Neighborhood influences on adolescent cigarette and alcohol use: Mediating effects through parent and peer behaviors. *J. Health Soc. Behav, 46 (2),* 187–204

Cohen, D.A., Ghosh-Dastidar, B., Scribner, R., Miu, A., Scott, M., Robinson, P., Farley, T.A., Bluthenthal, R.N., Brown-Taylor, D. (2006). Alcohol outlets, gonorrhea, and the Los Angeles civil unrest: a longitudinal analysis. *Soc. Sci. Med, 62 (12),* 3062–3071

Cohen, D. A., Inagami, S., & Finch, B. (2008). The built environment and collective efficacy. *Health & Place*, *14*(2), 198-208.

Crockett EG, Clancy KL, Bowering J. (1992). Comparing the cost of a thrifty food plan market basket in three areas of New York state. *J Nutria Educ*, 24, 71S– 8S.

Cummins, S., & Macintyre, S. (2006). Food environments and obesity: Neighborhood or nation? *International Journal of Epidemiology, 35,* 100-104.

Curtis KA, McClellan S. (1995). Falling through the safety net: Poverty, food assistance and shopping constraints in an American city. *Urban Anthropol, 24,* 93–135.

de la Barra, X. (2000). Fear of epidemics: The engine of urban planning. *Plann Pract Res*. 2000; 15:7–16.

Dearry, A. (2004). Impacts of our built environment on public health. *Environmental Health Perspectives*, *112*(11), A-600.

Diez-Roux, A. V. (2001). Investigating neighborhood and area effects on health. *American Journal of Public Health*, *91*(11), 1783-1789.

Diez-Roux, A. V. (2003a). Residential environments and cardiovascular risk. *Journal of Urban Health, 80*(4), 569-589.

Diez-Roux, A. V. (2003b). The examination of neighborhood effects on health: conceptual and methodological issues related to the presence of multiple levels of organization. *Neighborhoods and Health*, 45-64.

Diez-Roux, A. V. (2007). Neighborhoods and health: Where are we and where do we go from here? *Revue D'Epidemiologie et de Sante Publique*, *55*(1), 13-21.

DiMatteo MR, Giordani PJ, Lepper HS, & Croghan TW. (2002). Patient adherence and medical treatment outcomes: A meta-analysis. *Med Care 2002, 40,* 794–811.

DiMatteo MR. (2004). Variations in patients' adherence to medical recommendations: A quantitative review of 50 years of research. *Med Care, 42,* 200–209.

Duncan, D. T., Castro, M. C., Gortmaker, S. L., Aldstadt, J., Melly, S. J., & Bennett, G. G. (2012). Racial differences in the built environment–body mass index relationship? A geospatial analysis of adolescents in urban neighborhoods. *Int J Health Geogr*, *11*(11), 10-1186.

Duru, O. K., Gerzoff, R. B., Selby, J. V., Brown, A. F., Ackermann, R. T., Karter, A. J., ... & Mangione, C. M. (2009). Identifying risk factors for racial disparities in diabetes outcomes: the Translating Research into Action for Diabetes (TRIAD) Study. *Medical Care*, *47*(6), 700.

Dutton, D., & Levine, S. (1989). Overview, methodological critique, and reformulation. In J.P. Bunker, D.S. Gromby, & B.H.Kehrer (Eds.), *Pathways to Health* (pp. 29-69). Menlo Park, CA: The Henry J. Kaiser Family Foundation.

Ewing, R., Brownson, R.C., Berrigan, D., (2006). Relationship between urban sprawl and weight of United States youth. *American Journal of Preventive Medicine 31(6),* 464–474.

Farley, R., Steeh, C., Krysan, M., Jackson, T., & Reeves, K. (1994). Stereotypes and segregation: neighborhoods in the Detroit area. *American Journal of Sociology, 100(3),* 750-780.

Feagin, J. & Sikes, M. (1994). *Living with Racism: The Black Middle-Class Experience*. Boston: Beacon Press.

Feagin, J. (2013). *Systemic racism*. Routledge.

Feagin, J. R. (2014). *Racist America: Roots, current realities, and future reparations*. Routledge.

Feng, J., Glass, T. A., Curriero, F. C., Stewart, W. F., & Schwartz, B. S. (2010). The built environment and obesity: a systematic review of the epidemiologic evidence. *Health & Place*, *16*(2), 175-190.

Figaro K, Elasy T, BeLue R, Speroff T, & Dittus R. (2009). Exploring socioeconomic variations in diabetes control strategies: Impact of outcome expectations. *JNMA*, *101*, 18–23.

Fisher L & Glasgow RE. (2007). A call for more effectively integrating behavioral and social science principles into comprehensive diabetes care. *Diabetes Care, 30,* 2746–2749.

Fleischhacker, S., Rodriguez, D., Evenson, K., Henley, A., Gizlice, Z., Soto, D., & Ramachandran, G. (2012). Evidence for validity of five secondary data sources for enumerating retail food outlets in seven American Indian communities in North Carolina. *International Journal of Behavioral Nutrition and Physical Activity, 9 (137),* 1-14.

Frank, L.D., Andresen, M.A., Schmid, T.L., (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine, 27 (2),* 87–96.

Frank, L., Glanz, K., McCarron, M., Sallis, J., Sealens, B., & Chapman, J. (2006). The spatial distribution of food outlet type and quality around schools in differing built environment and demographic contexts. *Berkeley Planning Journal*, *19*(1).

Frank, L., Kerr, J., Saelens, B., Sallis, J., Glanz, K., & Chapman, J. (2009). Food outlet visits, physical activity and body weight: variations by gender and race–ethnicity. *British Journal of Sports Medicine*, *43(2)*, 124-131.

Frist, W. (2005). Overcoming disparities in U.S. health care. *Health Affairs, 24(2),* 445-451.

Frohlich, K., Ross, N., & Richmond, C. (2006). Health disparities in Canada today: Some evidence and a theoretical framework. *Health Policy*, *79*(2), 132-143.

Galvan FH & Caetano R. (2003). Alcohol use and related problems among ethnic minorities in the United States. *Alcohol Res Health, 27,* 87–94.

Gary TL, Crum RM, Cooper-Patrick L, Ford D, & Brancati FL. (2000). Depressive symptoms and metabolic control in African-Americans with type 2 diabetes. *Diabetes Care, 23,* 23–29.

Getis, A. and Ord, J.K.(1992). The Analysis of Spatial Association by Use of Distance Statistics. *Geographical Analysis 24(3),* 189-206.

Gordon-Larsen, P., Nelson, M. C., Page, P., & Popkin, B. M. (2006). Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*, *117*(2), 417-424.

Gorman, D.M., Speer, P.W., Gruenewald, P.J., Labouvie, E.W. (2001). Spatial dynamics of alcohol availability, neighborhood structure and violent crime. *J. Stud. Alcohol, 62 (5),* 628–636.

Green, C., Hoppa, R. D., Young, T. K., & Blanchard, J. F. (2003). Geographic analysis of diabetes prevalence in an urban area. *Social Science & Medicine*, *57*(3), 551-560.

Grier, S.A., and Kumanyika, S.K. (2008). The context for choice: Health implications of targeted food and beverage marketing to African Americans. *American Journal of Public Health*, *98*(9), 1,616-1,629.

Gruenewald, P.J., Ponicki, W.R., Holder, H.D. (1993). The relationship of outlet densities to alcohol consumption: A time series cross-sectional analysis. *Alcohol Clin. Exp. Res, 17 (1),* 38–47.

Gruenewald, P. J., Remer, L., & Lipton, R. (2002). Evaluating the alcohol environment: Community geography and alcohol problems. *Alcohol Research and Health*, *26*(1), 42-48.

Hall B. (1983). Neighborhood differences in retail food stores: income versus race and age of population. *Econ Geogr, 59,* 282–95.

Harris MI. (2001). Racial and ethnic differences in health care access and health outcomes for adults with type 2 diabetes. *Diabetes Care*, *24*, 454–459.

Harris, J.L., Pomeranz, J.L., Lobstein, T., and Brownell, K.D. (2009). A crisis in the marketplace: How food marketing contributes to childhood obesity and what can be done. *Annual Review of Public Health, 30*, 211-225.

Hartley, D. (2004). Rural health disparities, population health, and rural culture. *American Journal of Public Health*, *94*(10), 1675-1678.

Hatzenbuehler, M. L., Phelan, J. C., & Link, B. G. (2013). Stigma as a fundamental cause of population health inequalities. *American Journal of Public Health*, *103*(5), 813-821.

Heisler M, Faul JD, Hayward RA, Langa KM, Blaum C, & Weir D. (2007). Mechanisms for racial and ethnic disparities in glycemic control in middle-aged and older Americans in the health and retirement study. *Arch Intern Med, 167,* 1853–1860.

House, J. S., Kessler, R. C., & Herzog, A. R. (1990). Age, socioeconomic status, and health. *The Milbank Quarterly*, 383-411.

House, J. S. (2002). Understanding social factors and inequalities in health: 20th century progress and 21st century prospects. *Journal of health and social behavior*, 125-142.

Houston, D., Basolo, V., & Yang, D. (2013). Walkability, transit access, and traffic exposure for low-income residents with subsidized housing. *American Journal of Public Health, 103(4),* 673-678.

Hummer, R. A., Rogers, R. G., Nam, C. B., & LeClere, F. B. (1999). Race/ethnicity, nativity, and US adult mortality. *Social Science Quarterly,* 136-153.

Institute of Medicine. (2002). Unequal treatment: What healthcare providers need to know about racial and ethnic disparities in health-care.

Institute of Medicine. (2003). *The future of the public's health in the 21st century.* Washington, DC: National Academies of Press.

Institute of Medicine. (2006). *Food marketing to children and youth*: *Threat or opportunity?* J.M. McGinnis, J. Appleton Gootman, and V.I. Kraak (Eds.). Committee on Food Marketing and the Diets of Children and Youth. Washington, DC: The National Academies Press.

Jackson, R. J. (2003). The impact of the built environment on health: An emerging field. *American Journal of Public Health*, *93(9),* 1382-1384.

Kain, J. F. (1968). Housing segregation, Negro employment, and metropolitan decentralization. *The Quarterly Journal of Economics*, 175-197.

Karter, A. J., Ferrara, A., Liu, J. Y., Moffet, H. H., Ackerson, L. M., & Selby, J. V. (2002). Ethnic disparities in diabetic complications in an insured population. *JAMA*, *287*(19), 2519-2527.

Kaufman PR, MacDonald JM, Lutz SM, Smallwood DM. (1997). *Item selection and price differences affect low-income household food costs*. Washington DC: Economic Research Service, U.S. Department of Agriculture (Agricultural Economic Report 759).

King, W.C., Belle, S.J., Brach, J.S., Simkin-Silverman, L.R., Soska, T., Kriska, A.M., (2005). Objective measures of neighborhood environment and physical activity in older women. *American Journal of Preventive Medicine 28*, 461–469.

Krysan, M., & Farley, R. (2002). The residential preferences of blacks: Do they explain persistent segregation? *Social Forces*, *80*(3), 937-980.

Lake, A., & Townshend, T. (2006). Obesogenic environments: Exploring the built and food environments. *The Journal of the Royal society for the Promotion of Health*, *126*(6), 262-267.

Lantz, P., House, J., Lepkowski, J., Williams, D., Mero, R., & Chen, J. (1998). Socioeconomic factors, health behaviors, and mortality: Results from a nationally representative prospective study of US adults. *JAMA*, *279*(21), 1703-1708.

Laraia BA, Siega-Riz AM, Kaufman JS, Jones SJ. (2004) Proximity to supermarkets is positively associated with diet quality index for pregnancy. *Prev Med*, *39*, 869 –75.

Larson, N. I., Story, M. T., & Nelson, M. C. (2009). Neighborhood environments: disparities in access to healthy foods in the US. *American Journal of Preventive Medicine*, *36*(1), 74-81.

LaVeist, T., Thorpe Jr, R., Galarraga, J., Bower, K., & Gary-Webb, T. (2009). Environmental and socio-economic factors as contributors to racial disparities in diabetes prevalence. *Journal of General Internal Medicine*, *24*(10), 1144-1148.

Levine, R. S., Foster, J. E., Fullilove, R. E., Fullilove, M. T., Briggs, N. C., Hull, P. C., ... & Hennekens, C. H. (2001). Black-white inequalities in mortality and life expectancy, 1933-1999: Implications for Healthy People 2010. *Public Health Reports*, *116*(5), 474.

Li, F., Fisher, K.J., Brownson, R.C., Bosworth, M. (2005). Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. *Journal of Epidemiology and Community Health 59*, 558–564.

Li, F., Harmer, P., Cardinal, B. J., Bosworth, M., & Johnson-Shelton, D. (2009). Obesity and the built environment: Does the density of neighborhood fast-food outlets matter? *American Journal of Health Promotion*, *23*(3), 203-209.

Li, H., Campbell, H., & Fernandez, S. (2013). Residential segregation, spatial mismatch and economic growth across US metropolitan areas. *Urban Studies, 50(13),* 2642-2660.

Lieberson, S. (1985). *Making It Count: The Improvement of Social Research and Theory*. Berkeley: University of California Press.

Link, B., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior*, 80-94.

Link, B., & Phelan, J. (1996). Understanding sociodemographic differences in health--the role of fundamental social causes. *American Journal of Public Health*, *86*(4), 471-473.

Link, B., Northridge, M., Phelan, J., & Ganz, M. (1998). Social epidemiology and the fundamental cause concept: On the structuring of effective cancer screens by socioeconomic status. *Milbank Quarterly*, *76*(3), 375-402.

Link, B., & Phelan, J. (2002). McKeown and the idea that social conditions are fundamental causes of disease. *American Journal of Public Health*, *92*(5), 730-732.

Link, B., & Phelan, J. (2005). Fundamental sources of health inequalities. *Policy Challenges in Modern Health Care*, 71-84.

Link, B., Phelan, J., Miech, R., & Westin, E. (2008). The resources that matter: Fundamental social causes of health disparities and the challenge of intelligence. *Journal of Health and Social Behavior*, *49*(1), 72-91.

Link, B. (2008). Epidemiological sociology and the social shaping of population health. *Journal of Health and Social Behavior*, *49*(4), 367-384.

Link, C. L., & McKinlay, J. B. (2009). Disparities in the prevalence of diabetes: Is it race/ethnicity or socioeconomic status? Results from the Boston Area Community Health (BACH) survey. *Ethnicity & Disease*, *19*(3), 288.

Lipton, R., Gruenewald, P. (2002). The spatial dynamics of violence and alcohol outlets. *J. Stud. Alcohol, 63 (2),* 187–195.

Lleras, C. (2008). Race, racial concentration, and the dynamics of educational inequality across urban and suburban schools. *American Educational Research Journal*, *45*(4), 886-912.

Lovasi, G. S., Hutson, M. A., Guerra, M., & Neckerman, K. M. (2009). Built environments and obesity in disadvantaged populations. *Epidemiologic Reviews*, 1-14.

Luo, W., & Wang, F. (2003a). Spatial accessibility to primary care and physician shortage area designation: A case study in Illinois with GIS approaches. In: Skinner, R., Khan, O. (Eds.), *Geographic Information Systems and Health Applications*. Idea Group Publishing, Hershey, PA, pp. 260–278.

Luo, W., & Wang, F. (2003b). Measures of spatial accessibility to health care in a GIS environment: Synthesis and a case study in the Chicago region. *Environment and Planning B: Planning and Design. 30: 865–884.*

Mantovani RE, Daft L, Macaluso TF, Welsh J, Hoffman K. (1997). *Authorized food retailer characteristics study: Technical report IV authorized food retailers' characteristics and access study.* Alexandria VA: Office of Analysis and Evaluation, U.S. Department of Agriculture Food and Consumer Service.

Marchand, S., Wikler, D., & Landesman, B. (1998). Class, health, and justice. *Milbank Quarterly*, *76*(3), 449-467.

Marmot, M. G., Shipley, M. J., & Rose, G. (1984). Inequalities in death—specific explanations of a general pattern? *The Lancet*, *323*(8384), 1003-1006.

Maskarinec G, Grandinetti A, Matsuura G, Sharma S, Mau M, Henderson BE, & Kolonel LN. (2009). Diabetes prevalence and body mass index differ by ethnicity: The Multiethnic Cohort. *Ethn Dis, 19,* 49–55.

Massey, D. S., & Denton, N. A. (1989). Hypersegregation in US metropolitan areas: Black and Hispanic segregation along five dimensions. *Demography*, *26*(3), 373-391.

Massey, D., & Denton, N. (1993). *American apartheid: Segregation and the making of the underclass*. Harvard University Press.

McBean, A. M., Li, S., Gilbertson, D. T., & Collins, A. J. (2004). Differences in diabetes prevalence, incidence, and mortality among the elderly of four racial/ethnic groups: Whites, blacks, Hispanics, and Asians. *Diabetes Care*, *27*(10), 2317-2324.

McKinlay, J. (1996) – Some contributions from the social system to gender inequalities in heart disease. *Journal of Health and Social Behavior, 37,* 1-26.

McNeill, L. H., Kreuter, M. W., & Subramanian, S. V. (2006). Social environment and physical activity: a review of concepts and evidence. *Social Science & Medicine*, *63*(4), 1011-1022.

McWilliams, J. M., Meara, E., Zaslavsky, A. M., & Ayanian, J. Z. (2009). Differences in control of cardiovascular disease and diabetes by race, ethnicity, and education: US trends from 1999 to 2006 and effects of Medicare coverage. *Annals of Internal Medicine, 150*(8), 505-515.

Mechanic, D. (2002). Disadvantage, inequality, and social policy. *Health Affairs*, *21*(2), 48-59.

Millar, A.B., Gruenewald, P.J. (1997). Use of spatial models for community program evaluation of changes in alcohol outlet distribution. *Addiction, 92 (Suppl. 2),* S273–S283.

Miller ST, Schlundt DG, Larson C, Reid R, Pichert JW, Hargreaves M, Brown A, McClellan L, & Marrs M. (2010). Exploring ethnic disparities in diabetes, diabetes care, and lifestyle behaviors: The Nashville REACH 2010 community baseline survey. *Ethn Dis, 14(3 Suppl 1),* 38–45.

Mitchell, A. (2005). *The ESRI Guide to GIS Analysis,* Volume 2. ESRI Press.

Moore, L., Diez-Roux, A. (2006). Associations of neighborhood characteristics with the location and type of food stores. *American Journal of Public Health, 96,* 325-331

Morland, K., Wing, S., Diez-Roux, A., & Poole, C. (2002a). Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventative Medicine, 22(1),* 23-29.

Morland, K., Wing, S., & Diez-Roux, A. (2002b). The contextual effect of the local food environment on residents' diets: the atherosclerosis risk in communities study. *American Journal of Public Health*, *92*(11), 1761-1768.

Morris PM, Neuhauser L, Campbell C. (1992). Food security in rural America: A study of availability and cost of food. *J Nutr Educ, 24,* 52S– 8S.

National Center for Health Statistics (2015). Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, January–June 2015. Retrieved December 5, 2016 from http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201512.pdf

National Health Interview Survey. (2012, June 13). Retrieved December 15, 2014, from http://www.cdc.gov/nchs/nhis/about_nhis.htm.

National Institute of Health. (2000). *Strategic Research Plan and Budget to Reduce and Ultimately Eliminate Health Disparities.* Available at: http://ncmhd.nih.gov/strategicmock/our_programs/strategic/pubs/VolumeI_031003EDrev.pdf.

Northridge, M. E., Sclar, E. D., & Biswas, P. (2003). Sorting out the connections between the built environment and health: A conceptual framework for navigating pathways and planning healthy cities. *Journal of Urban Health-Bulletin of the New York Academy of Medicine*, *80*, 556–568.

Office of Disease Prevention and Health Promotion. (2015). Healthy People 2020: Disparities. Available online at http://www.healthypeople.gov/2020/about/foundation-health-measures/Disparities#5.

Parsons, V., & Schenker, N. (2008). County-level small area estimation using the National Health Interview Survey (NHIS) and the Behavioral Risk Factor Surveillance System (BRFSS). *Journal of Statistics and Mathematics*, 1100-1107.

Pfeffermann, D. (2013). New important developments in small area estimation. *Statistical Science*, *28*(1), 40-68.

Phelan, J., Link, B., Diez-Roux, A., Kawachi, I., & Levin, B. (2004). "Fundamental causes" of social inequalities in mortality: A test of the theory. *Journal of Health and Social Behavior*, *45*(3), 265- 285.

Phelan, J., & Link, B. (2005). Controlling disease and creating disparities: A fundamental cause perspective. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *60* (Special Issue 2), S27-S33.

Phelan, J., Link, B., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities: Theory, evidence, and policy implications. *Journal of Health and Social Behavior*, *51*(1 suppl), S28-S40.

Phelan, J. C., & Link, B. G. (2015). Is Racism a Fundamental Cause of Inequalities in Health? *Annual Review of Sociology*, *41*, 311-330.

Pierre, B. (1980). Le sens pratique. *Paris, Éditions de minuit*.

Plescia, M., Herrick, H., & Chavis, L. (2008). Improving health behaviors in an African American community: the Charlotte Racial and Ethnic Approaches to Community Health project. *American Journal of Public Health*, *98*(9), 1678.

Powell LM, Chaloupka FJ, Bao Y. (2007). The availability of fast-food and full-service restaurants in the United States: Associations with neighborhood characteristics. *Am J Prev Med, 33(4S),* S240–S245.

Quadagno, J. S. (1994). *Unfinished Democracy: Race, Rights, and the War on Poverty*. Oxford University Press.

Raghunathan, T. E., Xie, D., Schenker, N., Parsons, V. L., Davis, W. W., Dodd, K. W., & Feuer, E. J. (2007). Combining information from two surveys to estimate county-level prevalence rates of cancer risk factors and screening. *Journal of the American Statistical Association*, *102*(478), 474-486.

Reardon, S. F., & Yun, J. T. (2001). Suburban racial change and suburban school segregation, 1987–1995. *Sociology of Education*, *74*, 79–101.

Renalds, A., Smith, T. H., & Hale, P. J. (2010). A systematic review of built environment and health. *Family & Community Health*, *33*(1), 68-78.

Robert, S. A., & Ruel, E. (2006). Racial segregation and health disparities between black and white older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *61*(4), S203-S211.

Roof, K., Oleru, N. (2008). Public health: Seattle and King County's push for the built environment. *Journal of Environmental Health*, *71 (1)*, 24-27.

Ruel, E., & Robert, S. (2009). A model of racial residential history and its association with self-rated health and mortality among black and white adults in the United States. *Sociological Spectrum*, *29*(4), 443-466.

Ruel, E., Reither, E. N., Robert, S. A., & Lantz, P. M. (2010). Neighborhood effects on BMI trends: Examining BMI trajectories for Black and White women. *Health & Place*, *16*(2), 191-198.

Saha S, Arbelaez JJ, & Cooper LA. Patient-physician relationships and racial disparities in the quality of health care. *Am J Public Health, 93,* 1713–1719.

Sallis JF, Nader R, Atkins J. (1986). San Diego surveyed for heart healthy foods and exercise facilities. *Public Health Rep, 101,* 216–8.

Sallis, J. F., & Glanz, K. (2006). The role of built environments in physical activity, eating, and obesity in childhood. *The Future of Children*, *16*(1), 89-108.

Sampson, R. J. (1987). Urban black violence: The effect of male joblessness and family disruption. *American Journal of Sociology*, 348-382.

Sampson, R. J., & Wilson, W. J. (1995). Toward a theory of race, crime, and urban inequality. *Race, Crime, and Justice: A Reader*, 177-190.

Sampson, R. J., & Bean, L. (2006). Cultural mechanisms and killing fields: A revised theory of community-level racial inequality. *The many colors of crime: Inequalities of race, ethnicity, and crime in America*, 8-36.

Schneider EC, Zaslavsky AM, & Epstein AM. (2002). Racial disparities in the quality of care for enrollees in Medicare managed care. *JAMA, 287,* 1288–1294.

Schulz, A. J., Williams, D. R., Israel, B. A., & Lempert, L. B. (2002). Racial and spatial relations as fundamental determinants of health in Detroit. *Milbank Quarterly*, *80*(4), 677-707.

Sentell TL & Halpin HA. (2006). Importance of adult literacy in understanding health disparities. *J Gen Intern Med, 21,* 862–866.

Sequist, T. D., Fitzmaurice, G. M., Marshall, R., Shaykevich, S., Safran, D. G., & Ayanian, J. Z. (2008). Physician performance and racial disparities in diabetes mellitus care. *Archives of Internal Medicine*, *168*(11), 1145-1151.

Shuey, K. M., & Willson, A. E. (2008). Cumulative disadvantage and black-white disparities in life-course health trajectories. *Research on Aging*, *30*(2), 200-225.

Signorello, L. B., Schlundt, D. G., Cohen, S. S., Steinwandel, M. D., Buchowski, M. S., McLaughlin, J. K., ... & Blot, W. J. (2007). Comparing diabetes prevalence between African Americans and Whites of similar socioeconomic status. *American Journal of Public Health*, *97*(12), 2260-2267.

Singh, G., Miller, B., Hankey, B., Feuer, E., & Pickle, L. (2002). Changing area socioeconomic patterns in U.S. cancer mortality, 1950–1998: Part I—All cancers among men. Journal of the National Cancer Institute, 94, 904–915.

Small Area Estimates. (n.d.). Retrieved December 19, 2014, from http://sae.cancer.gov/

Smedley, BD. & Syme, SL. (2001). *Promoting Health: Intervention Strategies from Social and Behavioral Research*. National Academy Press; Washington, D.C.

Srinivasan, S., O'Fallon, L. R., & Dearry, A. (2003). Creating healthy communities, healthy homes, healthy people: Initiating a research agenda on the built environment and public health. *American Journal of Public Health*, *93*(9), 1446-1450.

Susser, M., Watson, W., & Hopper, K. (1985). *Sociology in Medicine*. New York: Oxford.

Tobler, W.R. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography, 46(suppl),* 234-240.

Urban Land Institute. (2013) *Intersections: Health and the Built Environment*. Washington, D.C.: Urban Land Institute.

USDA Food Atlas. (2010). Retrieved December 22, 2016 from https://www.ers.usda.gov/data-products/food-access-research-atlas/about-the-atlas/#definitions.

Wang, F., & Luo, W. (2005). Assessing spatial and nonspatial factors for healthcare access: Towards an integrated approach to defining health professional shortage areas. *Health & Place*, *11*(2), 131-146.

Weich, S., Burton, E., Blanchard, M., Prince, M., Sproston, K., & Erens, B. (2001). Measuring the built environment: Validity of a site survey instrument for use in urban settings. *Health & Place*, *7*(4), 283-292.

Weich, S., Blanchard, M., Prince, M., Burton, E., Erens, B. O. B., & Sproston, K. (2002). Mental health and the built environment: Cross-sectional survey of individual and contextual risk factors for depression. *The British Journal of Psychiatry*, *180*(5), 428-433.

Wilkes, R., & Iceland, J. (2004). Hypersegregation in the twenty-first century. *Demography, 41*(1), 23-36.

Williams, D. R., & Collins, C. (2001). Racial residential segregation: a fundamental cause of racial disparities in health. *Public Health Reports*, *116*(5), 404.

Williams, D. R., & Jackson, P. B. (2005). Social sources of racial disparities in health. *Health Affairs*, *24*(2), 325-334.

Williams, D. R., & Mohammed, S. A. (2009). Discrimination and racial disparities in health: Evidence and needed research. *Journal of Behavioral Medicine*, *32*(1), 20-47.

Williams, D., & Sternthal, M. (2010). Understanding racial-ethnic disparities in health: Sociological contributions. Journal of Health and Social Behavior, 51, S15-S27.

Willson, A. E. (2009). Fundamental Causes' of Health Disparities A Comparative Analysis of Canada and the United States. *International Sociology*, *24*(1), 93-113.

Wilson, W. J. (1996). Racial antagonisms and race-based social policy. *Great divides: Readings in social inequality in the United States*, 284-291.

Woolf, S. H., & Aron, L. (Eds.). (2013). *US Health in International Perspective: Shorter Lives, Poorer Health*. National Academies Press.

Wrigley N, Warm D, Margetts B, Whelan A. (2002) Assessing the impact of improved retail access on diet in a 'food desert': A preliminary report. *Urban Stud, 39,* 2061– 82.

Zenk, S. N., Schulz, A. J., Israel, B. A., James, S. A., Bao, S., & Wilson, M. L. (2005a). Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health*, *95(4)*, 660-667.

Zenk, S. N., Schulz, A. J., Hollis-Neely, T., Campbell, R. T., Holmes, N., Watkins, G., ... & Odoms-Young, A. (2005b). Fruit and vegetable intake in African Americans: Income and store characteristics. *American Journal of Preventive Medicine*, *29*(1), 1-9.

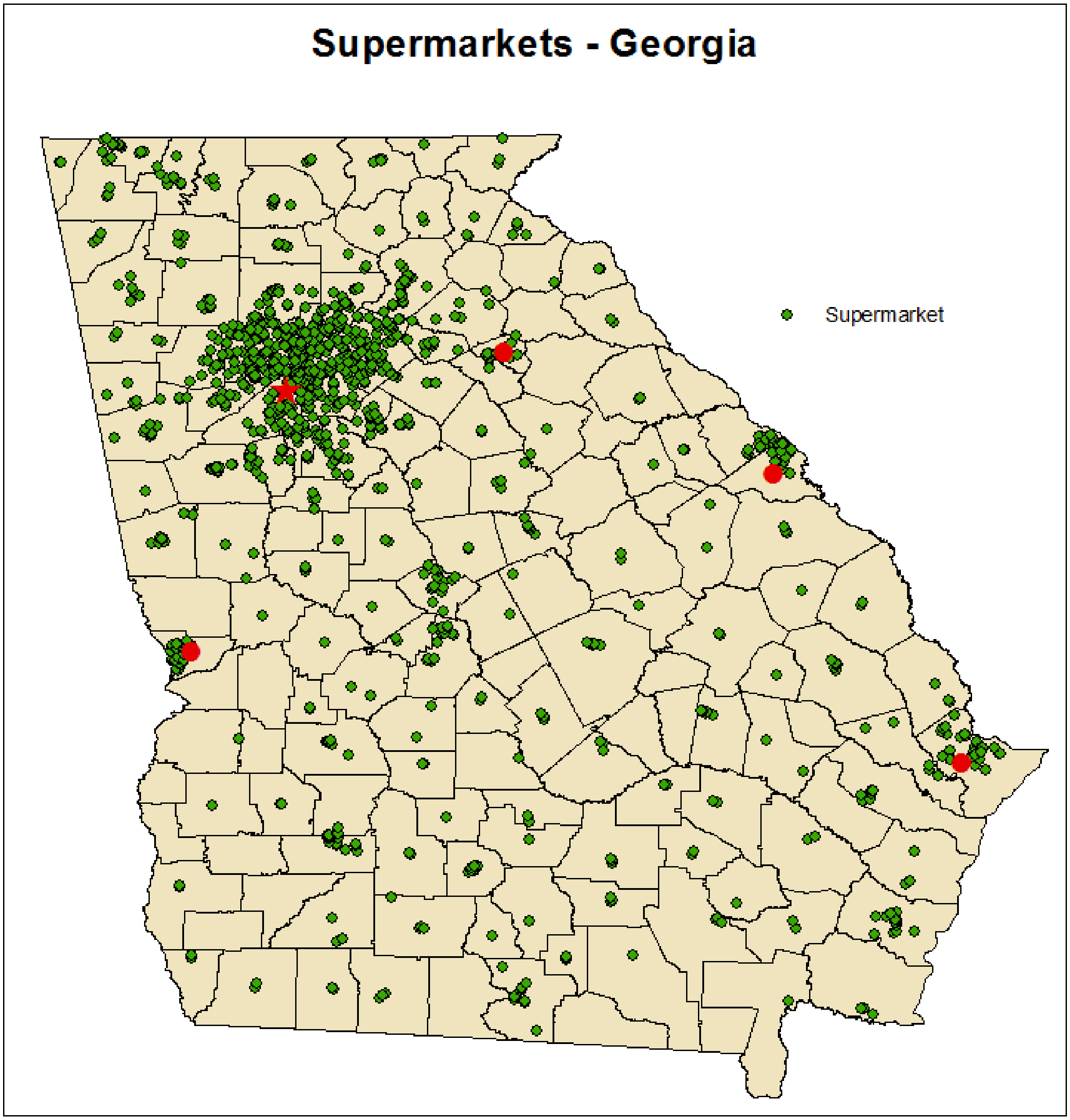
Zhang, Q., & Wang, Y. (2004). Socioeconomic inequality of obesity in the United States: Do gender, age, and ethnicity matter? *Social Science & Medicine*, *58*(6), 1171-1180.

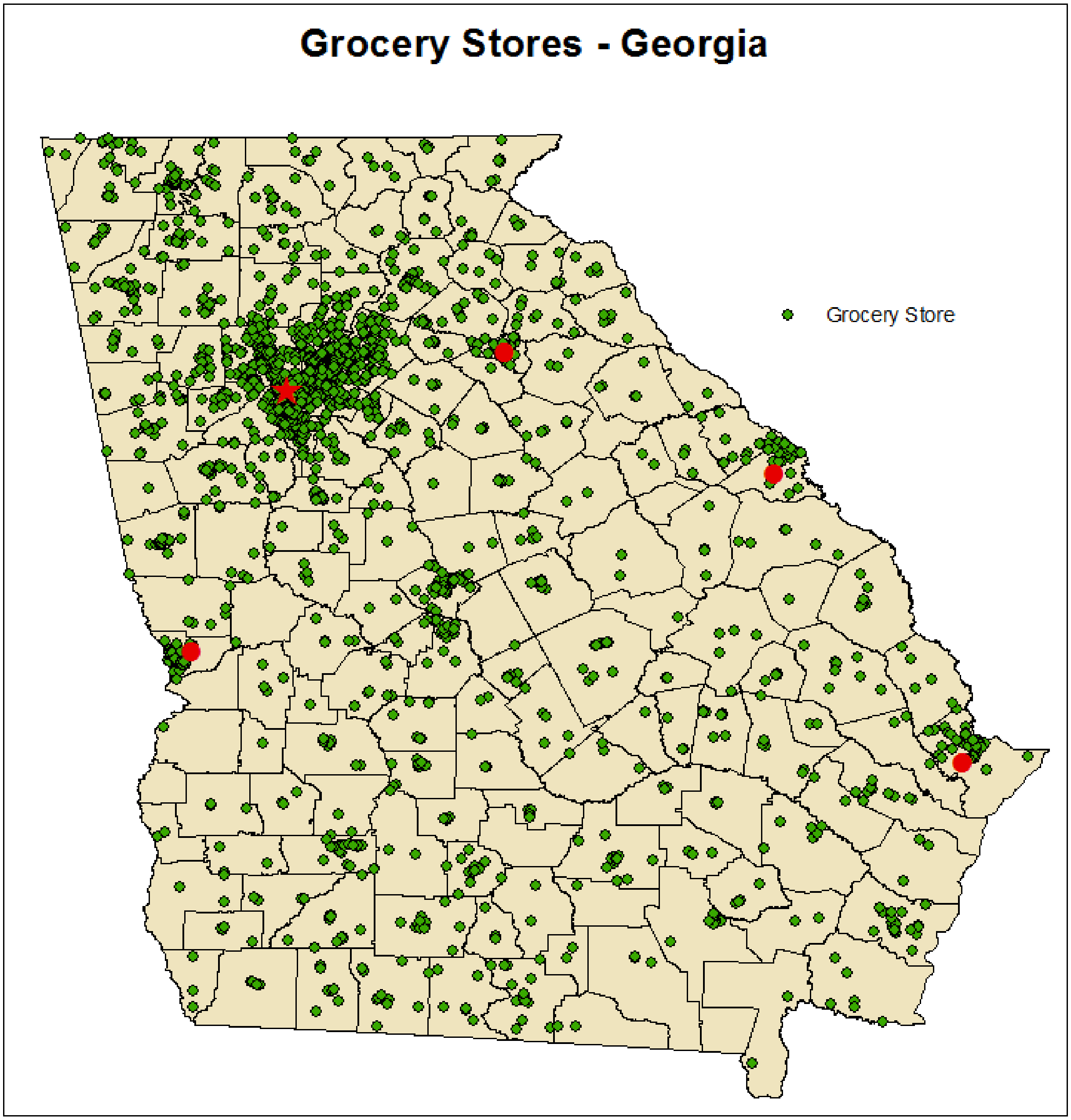
Zhang, Q., Wang, Y., & Huang, E. S. (2009). Changes in racial/ethnic disparities in the prevalence of Type 2 diabetes by obesity level among US adults. *Ethnicity & Health*, *14*(5), 439-457.

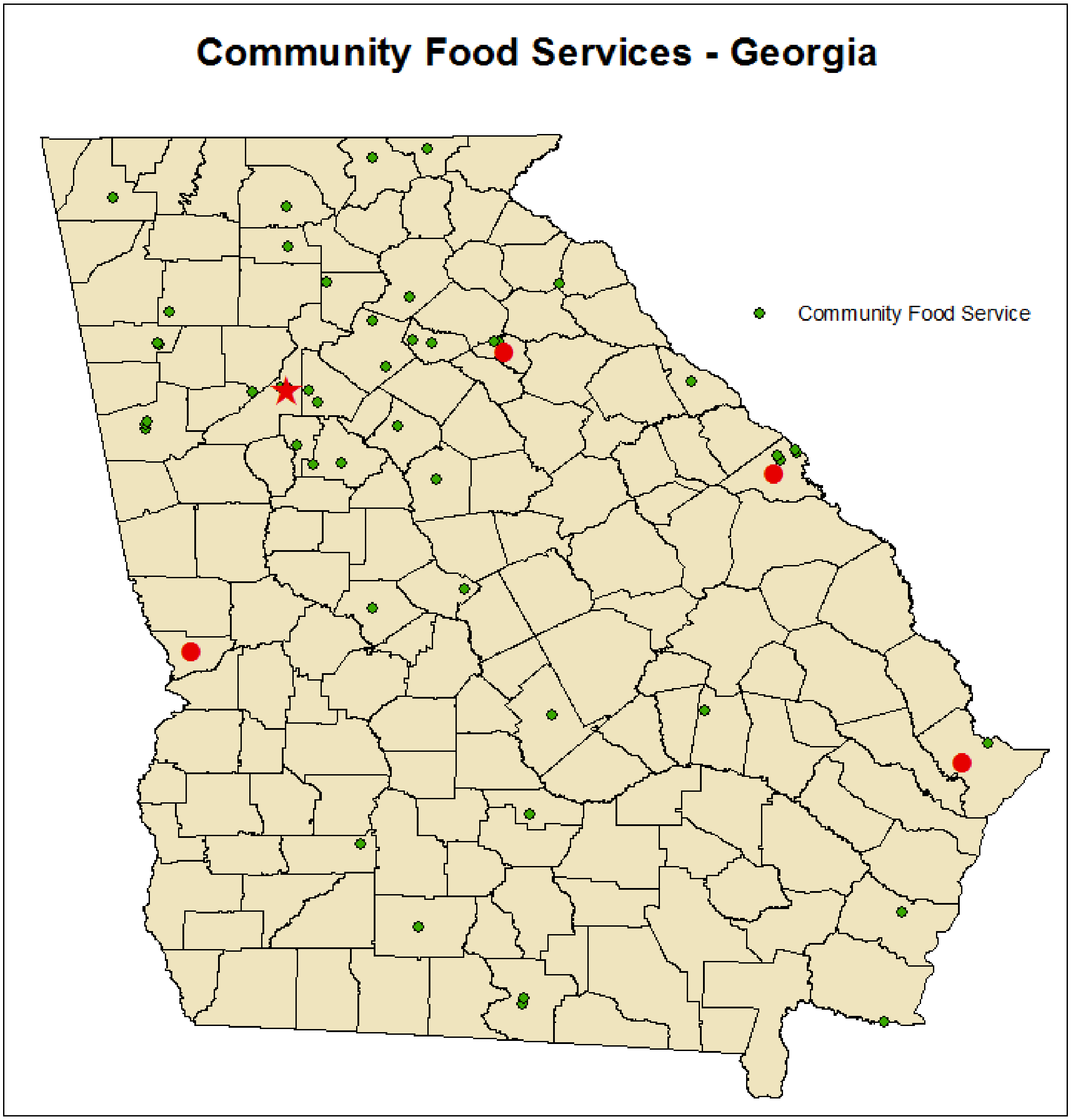
Zhang, Z., Zhang, L., Penman, A., & May, W. (2011). Using Small-Area Estimation Method to Calculate County-Level Prevalence of Obesity in Mississippi, 2007-2009. *Preventing Chronic Disease*, *8*(4).

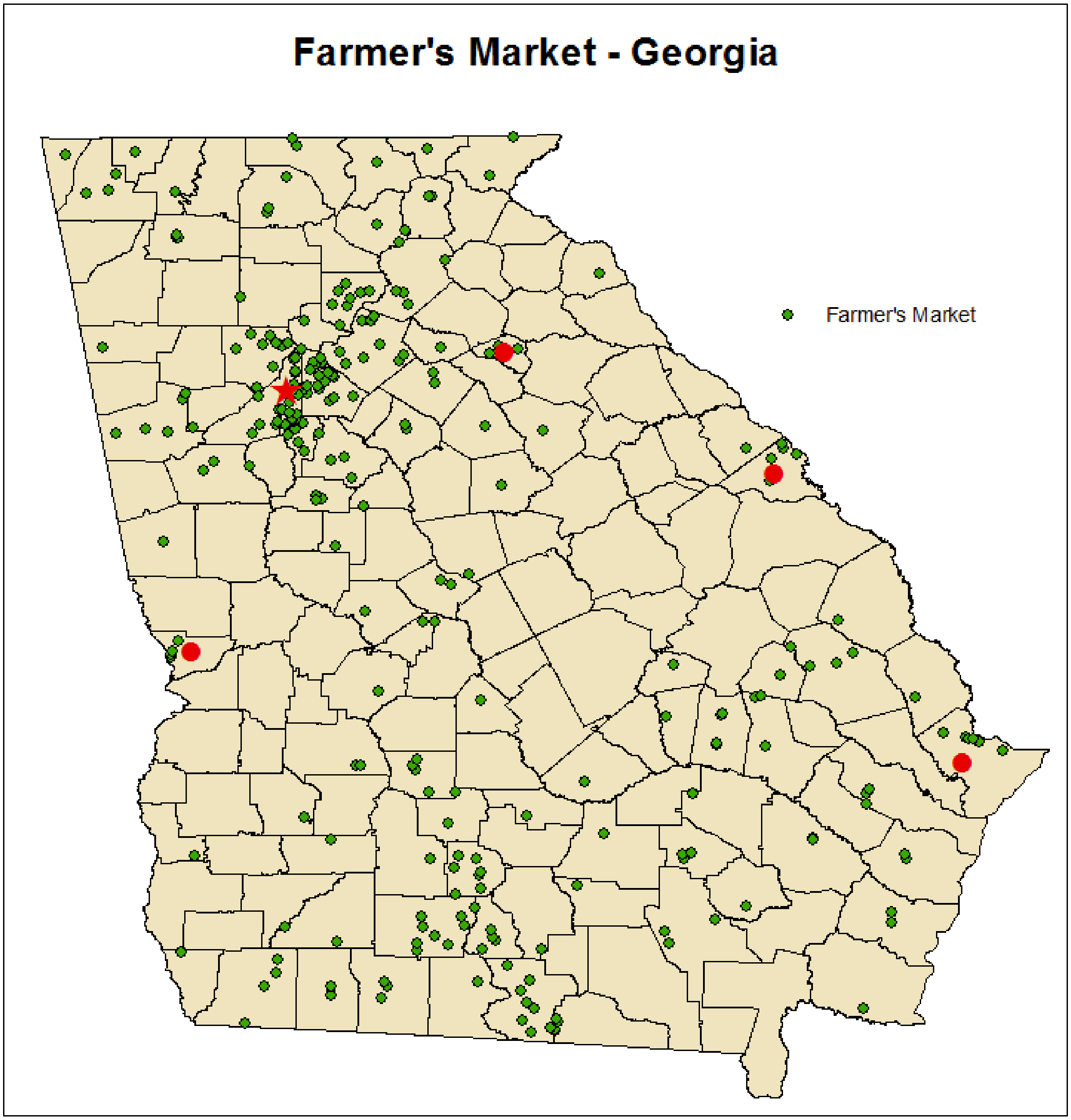
Zhu, L., Gorman, D.M., Horel, S. (2004). Alcohol outlet density and violence: A geospatial analysis. *Alcohol, 39 (4),* 369–375.

# APPENDIX A – BUILT ENVIRONMENT OUTLETS

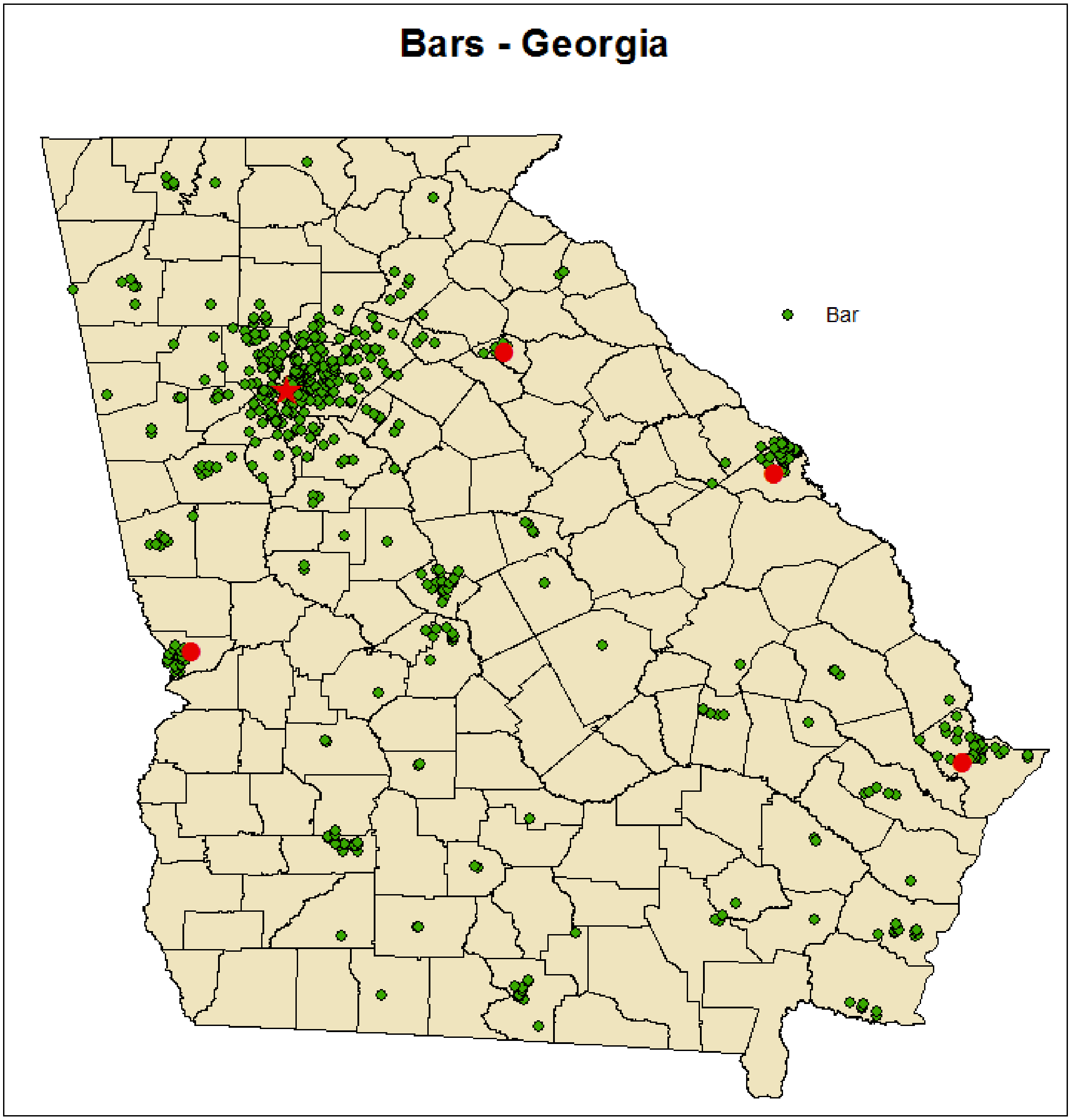


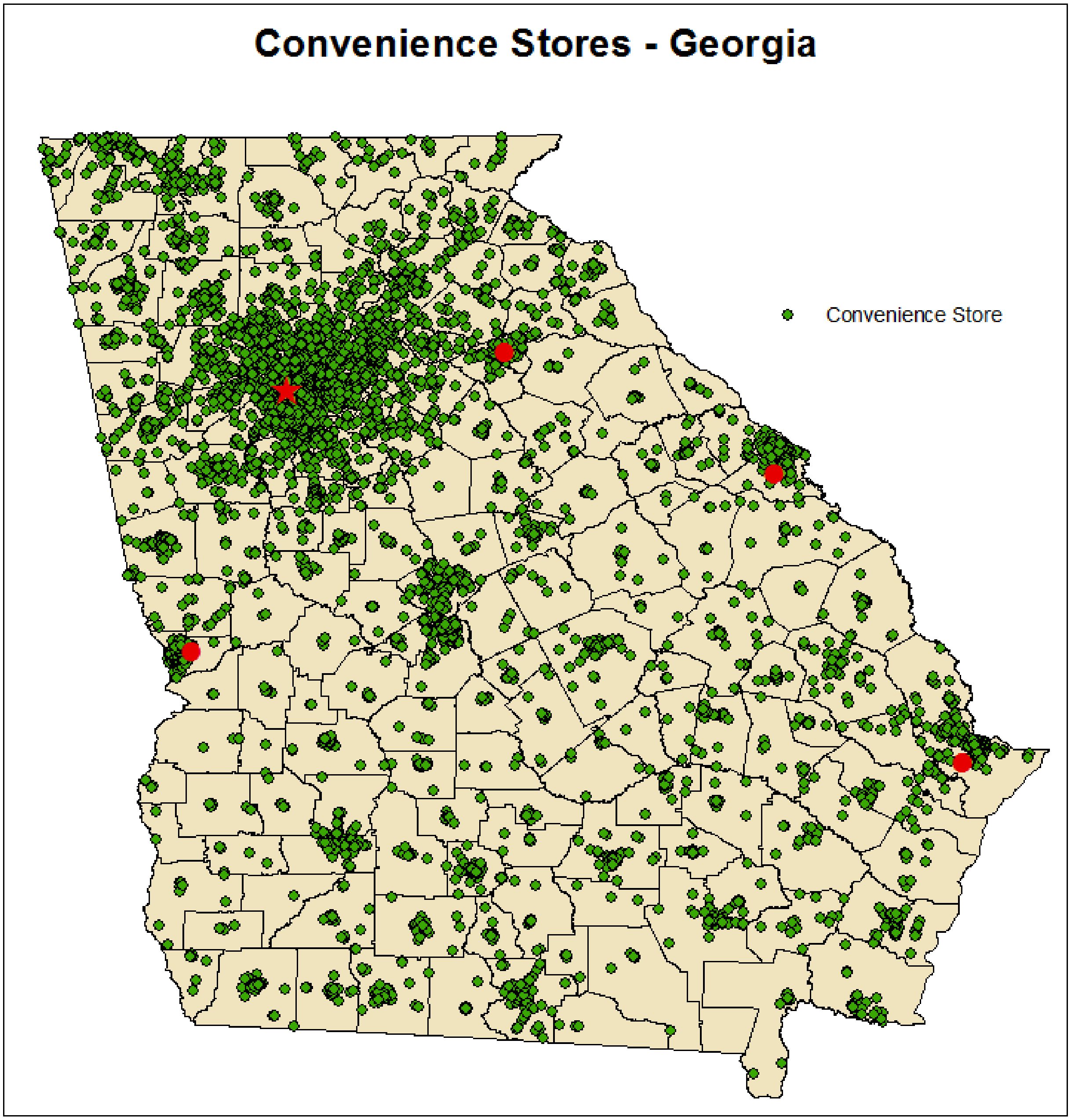

Grocery Stores - Georgia
Grocery Store

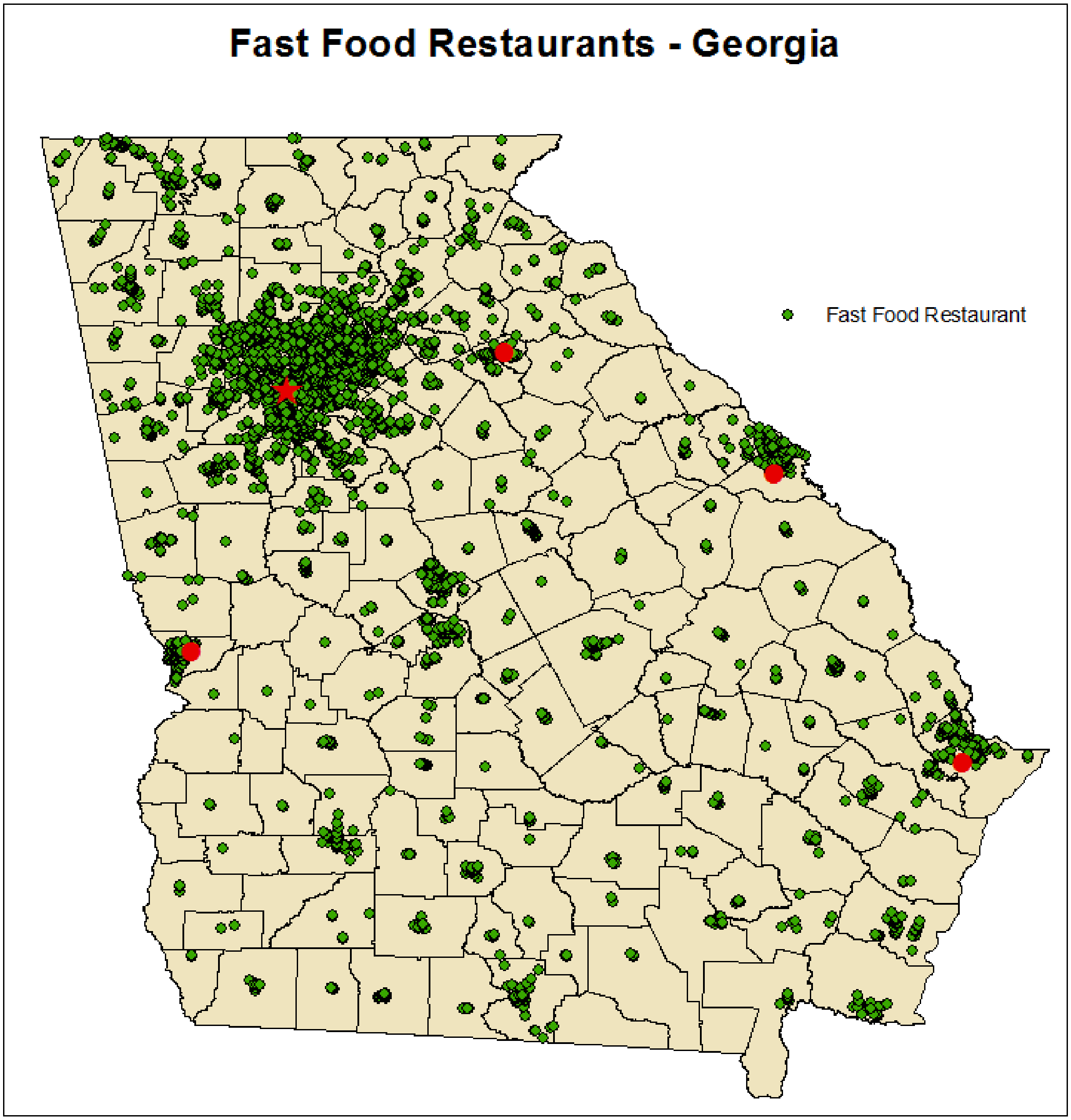

Community Food Services - Georgia
Community Food Service

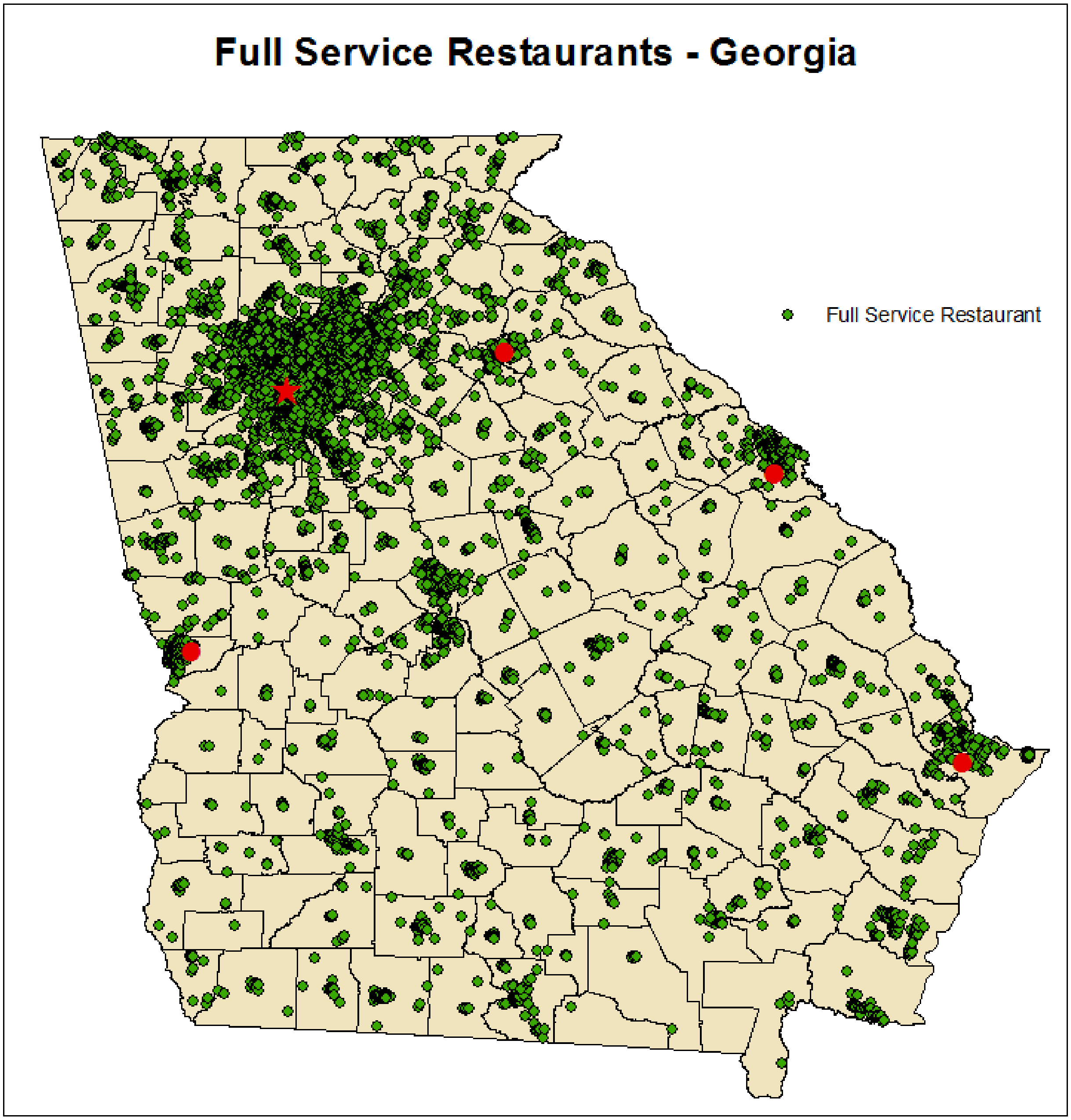


Farmer's Market - Georgia
Farmer's Market


Bars - Georgia
Bar


Convenience Stores - Georgia
Convenience Store


Fast Food Restaurants - Georgia
Fast Food Restaurant



Full Service Restaurants - Georgia
Full Service Restaurant


Liquor Stores - Georgia
Liquor Store

# APPENDIX B – CLUSTER ANALYSIS OF CRIME RATES IN GEORGIA